NATIONAL REVIEW OF CORPS ENVIRONMENTAL RESTORATION PROJECTS

Prepared by

Joy D. Muncy
U.S. Army Corps of Engineers
Water Resources Support Center
Institute for Water Resources
Alexandria, Virginia 22315-3868

and

Dr. J. Craig Fischenich
E. A. Dardeau
U.S. Army Corps of Engineers
Waterways Experiment Station
Vicksburg, Mississippi 39180-6199

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Preface

The work reported herein was conducted as part of the Evaluation of Environmental Investments Research Program (EEIRP). The EEIRP is sponsored by the Headquarters, U.S. Army Corps of Engineers (HQUSACE). It is jointly assigned to the U.S. Army Engineer Water Resources Support Center (WRSC), Institute for Water Resources (IWR), and the U.S. Army Engineer Waterways Experiment Station (WES), Environmental Laboratory (EL). Mr. William J. Hansen of IWR is the Program Manager and Mr. H. Roger Hamilton is the WES Manager. Technical Monitors during this study were Mr. John W. Bellinger and Mr. K. Brad Fowler, HQUSACE. The field review group members that provide complete Program direction and their District or Division affiliations are: Mr. David Carney, New Orleans District; Mr. Larry M. Kilgo, Lower Mississippi Valley Division; Mr. Richard Gorton, Omaha District; Mr. Bruce D. Carlson, St. Paul District; Mr. Glendon L. Coffee, Mobile District; Ms. Susan E. Durden, Savannah District; Mr. Scott Miner, San Francisco District; Mr. Robert F. Scott, Fort Worth District; Mr. Clifford J. Kidd, Baltimore District; Mr. Edwin J. Woodruff, North Pacific Division; and Dr. Michael Passmore, WES (formerly Walla Walla District.)

This report was prepared by Ms. Joy Muncy of the Technical Analysis and Research Division (TARD), IWR and Dr. Craig Fischenich and Mr. Tony Dardeau of the Environmental Engineering Division (EED), WES.

The report was prepared under the general supervision at EL of Mr. Norman R. Francingues, Chief, EED; Dr. John W. Keeley, Director, EL; and Dr. Robert W. Whalin, Director, WES and at IWR of Mr. Michael R. Krouse, Chief, TARD; and Mr. Kyle E. Schilling, Director, IWR.

This report evolved from the contributions of a myriad of Corps of Engineers reports, which are listed in the reference. We would like to acknowledge the many people from the various districts and divisions that took the time to discuss their projects, whether over the phone or by office visit, and to furnish us with copies of their studies.

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Chapter I - Introduction

The Corps of Engineers has assumed a leadership role in environmental restoration through its current and past activities. It has a mandate to include environmental features in all Corps projects at the earliest planning phase and to encourage environmental considerations through all phases of the project life. However, the Corps has lacked an integrated approach across programs and organizations that provide methods and procedures to formulate, design, and estimate costs for environmental projects.

Environmental features for Corps projects, by their nature, often apply less "structural" measures for achieving a stated planning objective. They often require ongoing monitoring and maintenance for vegetation and non-structural features that are not part of the traditional Operation and Maintenance (O&M) scope. In addition, local sponsors and outside interests want the Corps to consider the project area in a holistic view rather than in a site-specific manner when determining various types of alternatives in the early stages of plan formulation.

Historic engineering specifications often do not mesh with environmental objectives, and some individuals have expressed concern that there may be a tendency to over-design Corps environmental projects. The ability of local sponsors to cost-share may be compromised if unneeded detail and intensity of Corps designs result in higher cost plans and projects then needed. Water resource managers and study managers are looking for more diverse measures, including less detailed and intensive designs, to address ecosystem restoration objectives. Yet, little guidance is available to assist planners: 1) identify potential variables that could be modified to improve environmental outputs; 2) identify potential environmental management measures for modifying those variables; 3) identify the various engineering features or components of those management measures; 4) determine the associated probability of success of alternative management measures; and 5) estimate their costs.

This report provides descriptive information for water resource planners and managers concerning the engineering features of recently completed or on-going Corps environmental restoration projects. The report was prepared under the Engineering Environmental Investments - Formulating Inputs and Monitoring Effectiveness work unit of the Evaluation of Environmental Investments Research Program. The objectives of this work unit are to: 1) identify relevant approaches and features for environmental investment measures to be applied throughout the project life; 2) develop methods to assess the effectiveness of the approach or feature for providing the intended environmental output; 3) develop and provide guidance for formulating environmental projects; and 4) provide guidance for formulating and identifying relevant cost components of alternative restoration plans.

PURPOSE

The purpose of this report is to describe management measures, principally engineering features, explored and selected from a cross section of Corps districts and divisions. One or more management measures or engineering features can make up an alternative. The report responds to a need expressed by various study managers, project managers, engineers, water resource planners and managers, and others for descriptive information as to what management measures other district and division offices are considering when formulating environmental projects.

SCOPE

This report provides descriptive information from 52 Corps environmental restoration studies. For each project, information is provided concerning: its general location, the resource problems being addressed, objective(s), management measures, outputs, and estimated total costs. The 52 projects were selected from a review of over 80 Corps reports and fact sheets. They represent a cross-section in terms of geographic location, legislative authority under which undertaken, and types of engineering features recommended. They are also recently completed studies responsive to the concerns of over design. A companion document, National Review of Non-Corps Environmental Restoration Projects, (IWR Report 95-R-12) provides similar descriptive information for 39 non-Corps restoration projects. For this latter report, initially over 200 non-Corps projects were identified, approximately half of which were pursued for more detailed information. A common finding of both the Corps and non-Corps reviews, as was for many projects, there was insufficient documentation on specific management measures or costs for inclusion in the report summary.

The studies described in this report were conducted under several different legislative authorities, including: Section 1135(b) of the Water Resources Development Act (WRDA), 1986, as amended; the Upper Mississippi River System-Environmental Management Program (Section 1103 of WRDA 1986), and the Coastal Wetlands Planning, Protection, and Restoration Act (PL 101-646 and also known as the Breaux Bill). These authorities are explained in more detail later in this report. Other studies were conducted as part of flood control projects with environmental features and projects utilizing the beneficial uses of dredged material.

This report is not a critique or an analysis of these 52 Corps environmental restoration studies; its primary purpose is to provide descriptions of environmental management measures and/or engineering features and their costs. For example, the resource problems, objectives and outputs/benefits are provided only to assist the reader in better understanding the setting under which the management measures were being considered. This information was directly extracted or summarized from the study reports without critique or evaluation.

ORGANIZATION OF REPORT

This report consists of eight chapters. The introductory chapter includes the background information, the purpose, scope, organization of the report, and a summary table of the Corps projects subsequently described in more detail. Chapter 2 discusses various studies conducted under the Section 1135 authority. This chapter opens with a discussion of the Section 1135 authority; followed by the descriptions of 14 projects conducted under this authority. Chapter 3 addresses projects within the Upper Mississippi River System Environmental Management Program. It opens with a discussion of the program; followed by descriptions of 12 studies undertaken under this program. Coastal Wetlands Planning, Protection, and Restoration Act priority list projects are addressed in Chapter 4. Again, this chapter opens with a discussion of the program; followed by descriptions of 14 projects that fall under this authority. In Chapter 5 seven projects with both flood control and environmental features are described. Two of these projects used the Stream Obstruction Removal Guidelines (SORG). These guidelines were prepared by the Stream Renovation Guidelines Committee of the Wildlife Society and American Fisheries Society in cooperation with the International Association of Fish and Wildlife Agencies. Five projects associated with the beneficial uses of dredged material are described in Chapter 6. Chapter 7 presents several tables of unit pricing of engineering features from some of these projects and also includes a detailed explanation on how to follow the tables at the beginning of the chapter.

Conclusions and recommendations for further work are presented in Chapter 8. The report concludes with a reference section.

SUMMARY OF PROJECTS

Descriptions of 52 Corps projects from 16 different districts and divisions are presented in this report. A summary of these projects is presented in Table 1, by authority or project type. Information in this table includes: name, responsible district or division, a shortened version of the project's goals and objectives, the major engineering features or management measures for each project, the project benefits and/or outputs, and the estimated project cost. The project cost will be given in the price level from the report and in an updated price level as of October 1995. These updated costs were calculated using the Civil Works Construction Cost Index System (CWCCIS) EM 1110-2-1304. In the following chapters, the updated costs will be shown in (parenthesis) following the costs from the study report.

OTHER RELATED REPORTS

Other reports either completed or underway from the Engineering Environmental Investments - Formulating Inputs and Monitoring Effectiveness work unit include:

Prototype Information Tree for Environmental Restoration Plan Formulation and Cost Estimation, IWR Report 95-R-3, March 1995 - This report focused on three specific objectives: 1) developing a prototype information tree structure to provide and organize data and information useful for environmental restoration plan formulation and cost estimation; 2) describing the content of the tree branches and their linkages; and 3) beginning the process of building the tree database, and identifying additional data sources and data deficiencies with respect to its more complete implementation.

The report describes the conceptual development of an information tree to assist in the design of environmental restoration projects. It examines and illustrates various environmental assessment techniques used by project planners to identify site deficiencies with respect to project goals. It focused on developing the "roots" of the tree which link the results of environmental assessments (i.e., target variables) with the main stem. A primary consideration for developing the tree structure was how site-specific factors might be reflected in the various tree branches.

National Review of Non-Corps Environmental Restoration Projects, IWR Report 95-R-12, December 1995 - This report compiled management measures, engineering features, monitoring features, and detailed costs for a representative sample of non-USACE environmental projects or engineering projects with environmental features, which is similar to this report. Both reports will be used to further develop the Information Tree Report. The information will be used to assist planners in the following: 1) identifying potential environmental variables that can be manipulated to improve environmental outputs; 2) identifying alternative management measures for modifying those variables; 3) identifying the various engineering features or components of those management measures; 4) determining the associated probability of success of alternative management measures; and 5) estimating their costs.

Planning Aquatic Ecosystem Restoration Monitoring Programs, IWR 96-R-13, November 1996 - This forthcoming report will provide a systematic approach to planning, implementing, and interpreting monitoring programs for restoration projects. This report will discuss how a monitoring program proceeds from identification of goals through selecting monitoring methods, and finally to interpretation and dissemination of results. The use of monitoring results to implement corrective actions will also be described. This report is not a "how to" manual of the specifics of sampling, sample processing, statistical processing, statistical analysis, etc., but rather a guide to developing a monitoring program for aquatic restoration.

The report will be directed at USACE planners to help them identify factors to consider in a monitoring program, and to design and implement an efficient, cost-effective program. The information may also be helpful to others involved in mitigation and restoration projects, including resource managers, developers, aquatic scientists, landscape architects and engineers.

Illustrated Handbook - Also currently underway is an illustrated handbook depicting various types of engineering features and an interpretation of each of the features depicted. Illustrations will include photographs and sketches.

Procedures Manual - The procedures manual, when completed, will be a summation of all the tools and products developed under this work unit. This report will be based on and expand upon the concepts presented.

TABLE 1 - SUMMARY OF PROJECTS

Project Name/District	District or Division	Primary Project Objectives and Goals	Major Engineering Features	Benefits and/or Outputs	Cost
Section 1135 Projects					
Boyer Chute, Nebraska	Omaha District	Restore and enhance aquatic and terrestrial habitat.	Notching revetment closure, excavating pilot channel, lowering existing closure structure, replacing culvert with bridge, constructing new stone bed stabilization structure, and removing stone to achieve notch.	Gain 40 acres flowing water; Replace 15 acres of backwater wetland, 10 acres of mudflats, and 15 acres of young forest and wet meadows.	$2,300,000 (Apr 93) $2,400,000 (Oct 95)
Carlyle Lake, Kaskaskia River, Illinois	St. Louis District	Improve flows between subunits and main ditch; Remove sediment pockets; Improve ditch system; Subdivide pools; Provide flood protection to levees.	Twenty-four new gated culverts.	Intangible benefits to migratory birds and improve wildlife management.	$954, 000 (Oct 92) $1,040,177 (Oct 95)
Fern Ridge Lake, Long Tom River, Oregon	Portland District	Provide 200,000 Waterfowl Use Days.	Three impoundments, irrigation water supply pump, and overflow spillways, and drainage culverts with positive closure gates.	200,000 Waterfowl Use Days, other nonmonetary benefits for other species.	$298,604 (using BLM) $523,409 (conventional contracting) (Jun 92) $326,194 & $570,516 (Oct 95)
Galilee Salt Marsh, Narragansett, Rhode Island	New England Division	Restore salt marsh.	Excavate former main channel, construct twin culverts and stoplogs, excavate former natural channels, and dispose excavated material within the site.	Restore approximately 34 acres of salt marsh habitat.	$1,576,600 (Jun 93) $1,671,196 (Oct 95)
Homme Lake, North Dakota	St. Paul District	Increase nesting habitat for wildlife and to increase the overall value.	Potholes/Waterfowl pair ponds, nesting structures/culverts, and culvert and half-round standpipe/stoplog control structure.	Improved vegetation substrate; increase in aquatic invertebrates, breeding and nesting waterfowl habitat.	$36,000 (Mar 91) $40,488 (Oct 95)

Project Name/District	District or Division	Primary Project Objectives and Goals	Major Engineering Features	Benefits and/or Outputs	Cost
Houma Navigation Canal, Louisiana	New Orleans District	Restore barrier islands.	Beneficial use of dredged material and vegetated - retention/erosion control structure.	Creating 40 acres.	$607,000 (Jul 93) $644,817 (Oct 95)
Laguna Madre Seagrass Project, Texas	Galveston District	Determine whether transplanting seagrass will increase rate of recovery of seagrass habitat and associated resources.	Transplant seagrass from nearby naturally occurring sources onto freshly deposited dredged material in open-bay disposal areas.	If successful, procedure can be used in other estuarine areas with similar environment to reduce recovery time.	$287,500 (Oct 94) $295,841 (Oct 95)
Lake Winnibigoshish, Minnesota	St. Paul District	Restore wetlands to natural floodplain wetlands.	Water intake pipe, gate valve upstream and system of valves downstream of ponds; each pond with water inlet and outlet structures.	Restoring 44 acres of wetlands.	$74,600 (Jan 93) $79,822 (Oct 95)
Lower Truckee River, Nevada	Sacramento District	Improve river habitat for resident fish and wildlife; Federally endangered and threatened species.	Twenty-six management measures categorized into three alternative river management plans. See Table 5.	Reduction in dredging costs; savings in hatchery operations; improved cattle grazing benefit cost; flood control; river channel stabilization; and economic benefits.	See Tables 6-8
McFaddin Ranch Wetlands, Texas	Galveston District	Reduce saltwater intrusion.	Gated concrete water control structure; intake outlet channels; dam existing outlet channel; instal boat roller system; riprap; and training levees.	155 percent improvement above the without project condition.	$1,945,000 (Feb 92) $2,139,500 (Oct 95)
Orwell Lake, Minnesota	St. Paul District	Restore wetlands on project lands; to increase habitat value; to restore upland nesting habitat for wildlife; and to increase overall value of project lands.	Construct impoundments; control structures; and upland plantings.	Approximately 190 acres directly affected.	$224,000 (Oct 92) $244,160 (Oct 95)

Project Name/District	District or Division	Primary Project Objectives and Goals	Major Engineering Features	Benefits and/or Outputs	Cost
Sammamish River, Washington	Seattle District	Restore the stream channel to provide improved habitat for fish and wildlife.	Three sites - Create meandering channel; log sills; vegetation; footbridge; log habitat features; excavation and benching; quarry spalls; and low flow deflectors.	Fish spawning and migrating benefits; wildlife benefits; water quality benefits; and aesthetic appearance improved.	$440,000 (Oct 93) $466,400 (Oct 95)
Sonoma Baylands Tidal Wetlands, California	San Francisco District	Restore a diked, subsided former tidal wetland.	Construct levee and peninsulas; dredged material	Restore 31 acres of intertidal mudflat and wetland habitat and peripheral terrestrial habitat.	$792,000 (Feb 92) $871,200 (Oct 95)
Yolo Basin Wetlands and Davis Site, California	Sacramento District	Restore historic wetlands.	Low berms and excavation; stormwater tract (earthen diversion channel) and pump station; island creation.	Yolo Basin - 2 Sites. Site 1 - 1,447 AAHU Site 2 - 168 AAHU Davis Site - 118 AAHU	Site 1 - $3,210,000 Site 2 - $840,000 Davis St - $1,670,000 (Oct. 91) $3,595,200; $940,800; $1,870,400 (Oct 95)

Project Name/District	District or Division	Primary Project Objectives and Goals	Major Engineering Features	Benefits and/or Outputs	Cost
Upper Mississippi River System - Environmental Management Projects					
Bay Island, Missouri	Rock Island District	Provide controlled water levels over forested and non-forested areas; increase mast tree dominance; and increase total wetland values.	Waterfowl Management Units - Earthen perimeter levees, pump station, and stoplog structures; also planting mast tree species, water control plan, wells, pump station, water control structures, levee, and levee borrow.	Potential improvement of 360 percent for migratory waterfowl.	$1,075,000 (Dec 89) $1,247,000 (Oct 95)
Brown's Lake, Iowa	Rock Island District	Reduce sedimentation, improve water quality, increase fish habitat, diversity and habitat available for wintering, and increase bottomland hardwood diversity.	Deflection levee, water control structure, side access channel excavation, lake dredging and replanting.	Provide a commensurate increase of habitat rehabilitation and enhancement consistent with estimated cost.	$2,873,000 (Jun 87) $3,619,980 (Oct 95)
Bussey Lake, Iowa	St. Paul District	Reduce aquatic plant cover, increase vegetative/non-vegetative cover, increase variety of water depths, and increase diversity of substrate types.	Dredging and dredge disposal; create new moist soil unit; water control structures.	Establishing 29 acres of deeper water with reduced vegetation growth, creation of approximately 27,000 linear feet of open water/vegetation bed edge, increase in bathymetric diversity and sediment and contaminant prevention.	$1,684,000 (Apr 90) $1,919,760 (Oct 95)
Finger Lakes, Minnesota	St. Paul District	Increase the amount of available fish habitat by stabilizing oxygen levels of greater than 5 mg/l.	Single gate well structures and culverts.	Improve 113 acres of aquatic habitat.	$790,000 (May 90) $900,600 (Oct 95)

Project Name/District	District or Division	Primary Project Objectives and Goals	Major Engineering Features	Benefits and/or Outputs	Cost
Lake Chautauqua, Illinois	Rock Island District	Increase submergent and emergent vegetation, create flowing side channel and deepwater slough habitat, and reduce sedimentation.	Raising existing levees and cross dike, modify existing radial gate structure, pump station, gated gravity outlets, drainage channels, boat ramp, side channel entrance closure structure, and excavating side channel.	Provide 3,250 acres of manageable aquatic and wetland habitat and approximately 8,400 feet of flowing side channel.	$4,113,000 (Feb 91) $4,606,560 (Oct 95)
Peoria Lake, Illinois	Rock Island District	Increase reliable food production and resting area for waterfowl, increase diversity and areal extent of submergent and emergent vegetation, and provide flowing side channel habitat.	Forested wetland management area - levees to form controlled ponding units, pump station and piping, and stoplog structures; Barrier island - mechanical excavation, vegetation, floating vegetated islands; Side channel excavation.	Improve the existing aquatic habitat by approximately 200 percent.	$4,237,000 (Feb 90) $4,872,550 (Oct 95)
Pharrs Island, Missouri	St. Louis District	Decrease sedimentation, control water levels, increase food production, increase quantity of river slackwater habitat, increase photic zone and available cover, and increase total wetland values.	Rock dike, levee, borrow area, culvert drain with a gatewell-protected sluice gate, portable pump, dredging and vegetation.	Eliminate approximately 96 percent of future input of sedimentation; net gain for waterfowl of 118 AAHUs and large slackwater fish of 51 AAHUs.	$2,783,250 (Oct 89) $3,228,570 (Oct 95)
Pool 8 Islands, Wisconsin	St. Paul District	Reestablish islands, grass/shrub/herbaceous vegetative cover, increase sheltered-shallow and sheltered deep habitat and reduce sedimentation.	Form one interconnected island and construct second major island - Dredge material, riprap, topsoil and, vegetation.	Preserve existing 400 acres of backwater habitat, increase protected shallow and deep-water habitat of 100 and 30 acres, resp., with positive effects of an additional 355 acres.	$1,213,400 (Jun 89) $1,407,544 (Oct 95)

Project Name/District	District or Division	Primary Project Objectives and Goals	Major Engineering Features	Benefits and/or Outputs	Cost
Potters Marsh, Illinois	Rock Island District	Restore and create fisheries habitat, reduce sediment input, increase bird habitat.	Create sediment trap, hydraulically dredge backwater channels, potholes, develop managed marshland and grassland.	Provide approximately 32 acres of manageable aquatic and wetland habitat and 38 acre-feet of off-channel, deep-water aquatic habitat.	$3,957,000 (Nov 91) $4,392,270 (Oct 95)
Spring Lake, Illinois	Rock Island District	Improve water quality for fish, maintain backwater lake, provide reliable wetland vegetation and food source.	Independent water-controlled cells, gated controlled inlet structure, excavated channels, water-controlled hemi-marsh, and restoring perimeter levee.	Three sites - habitat improvements. Site 1 - 157 percent. Site 2 - 407 percent. Site 3 - 99 percent.	$5,849,000 (Oct 92) $6,375,410 (Oct 95)
Stump Lake, Illinois	St. Louis District	Reduce sedimentation, improve water level control, seasonal slackwater fish habitat, fish spawning and photic zone.	Low sediment deflection levee, low-level interior levees, sluice-gated CMP structures, stoplog drainage structures, sluice-gated concrete “Fish Passage” structures, concrete fish passage and water control structure, remove stoplog structure, electronic river gauge station, dredging, and reversible pump station.	Net increase of 753 AAHUs and a 79 percent reduction in sediment carrying waters into project area.	$4,059,300 (Oct 90) $4,587,009 (Oct 95)
Swan Lake, Illinois	St. Louis District	Reduce sedimentation, maintain steady water levels, solidify lake bottom, wave control, form smaller independently managed lake units, areas of deep water, free movement of fish between river and dike, buffer impact of cold water and ice, assure fish passage.	Riverside dike or levee, interior lake closure, water and sediment control traps, island groups, gated CMP, couch pumps, and boat access.	New gain of 1,021 AAHUs for waterfowl and 669 AAHUs for slackwater fish.	$7,854,000 (Dec 92) $8,482,320 (Oct 95)

Project Name/District	District or Division	Primary Project Objectives and Goals	Major Engineering Features	Benefits and/or Outputs	Cost
Coastal Wetlands Planning and Restoration Act					
Atchafalaya Bay Booster Pump Marsh Creation, Louisiana	New Orleans District	Create new vegetated wetlands within a shallow open water disposal site.	Dredging.	Provide 86 AAHUs.	$1,091,000 (Oct 93) $1,156,460 (Oct 95)
Black Bayou Culverts Hydrologic Restoration, Louisiana	New Orleans District	Provide fresh water, nutrients, and some sediments to brackish marshes.	Gated box culverts.	Provide 650 AAHUs.	$9,639,000 (Oct 93) $10,217,340 (Oct 95)
Channel Armor Gap Crevasse, Mississippi River, Louisiana	New Orleans District	Utilize available sediment in areas which are currently shallow open water bottoms to create emergent marshes.	Enhancing existing structures and channels, i.e., deepening invert of existing gap in channel bank armor, enlarge existing earthen channel, and excavate and cast material.	Net Gain of 936 acres is expected	$665,000 (Oct 93) $704,900 (Oct 95)
Eastern Isle Dernieres Barrier Island Restoration, Louisiana	New Orleans District	Restore coastal dunes and wetlands and enhance physical integrity of islands, and protect estuary and associated vegetated wetlands against exposure to Gulf of Mexico.	Build up dunes with overwash sediments, close breaches with emergent sands and build retaining structure behind and over which dredged material will be pumped. Elevated platform planted.	Create approximately 105 acres of saline marsh.	$5,414,000 (Oct 93) $5,738,840 (Oct 95)
GIWW/Freshwater Bayou Bank Stabilization, Louisiana	New Orleans District	Prevent erosion.	Riprap	Provide 13 AAHUs.	$2,026,000 (Oct 93) $2,147,560 (Oct 95)
Lake Anthanasio Spit Marsh Creation, Louisiana	New Orleans District	Preserve spit.	Dredging and pumping	Total benefitted acres will be 1,694.	$866,00 (Oct 93) above Federal Standard. $917,960 (Oct 95)
Marsh Creation - Barataria Bay Waterway Maintenance Dredging, Louisiana	New Orleans District	Create vegetated wetland using dredged sediments.	Dredge sediments used for maintenance to confined areas and seeded.	Create 450 acres.	$1,125,000 (Oct 91) $1,260,000 (Oct 95)

Project Name/District	District or Division	Primary Project Objectives and Goals	Major Engineering Features	Benefits and/or Outputs	Cost
Marsh Creation - Bayou La Branche Wetlands, Louisiana	New Orleans District	Create new vegetated wetlands and restore and nourish deteriorated marshes.	Dredge sediments and seeded. 70% of area to hold sediment.	Create 254 acres.	$4,327,000 (Jul 91) $4,846,240 (Oct 95)
Marsh Protection - Lake Salvador Shoreline Protection, Louisiana	New Orleans District	Protect vegetated wetlands.	Multi-celled sand-filled fabric bag breakwater to trap sediments.	Protect 90 acres. Approximately 11 acres of new wetlands may develop.	$1,106,000 (Oct 91) $1,238,720 (Oct 95)
Marsh Creation - Tiger Pass Maintenance Dredging, Louisiana	New Orleans District	Create vegetated wetlands.	Dredge sediments for maintenance and deposited and seeded.	Create approximately 460 acres.	$670,000 (Oct 91) $750,400 (Oct 95)
Marsh Creation with Uncontrolled Sediment Diversion from the Mississippi River West Bay Sediment Diversion, Louisiana	New Orleans District	Create vegetated wetlands.	Earthen broad crested weir and conveyance channel, pipe relocation, sediment retention dikes, and dredging.	Creating and benefiting 10,720 acres.	$2,644,000 (Oct 91) $2,961,280 (Oct 95)
Mississippi River Gulf Outlet Disposal Area Marsh Protection, Louisiana	New Orleans District	Protect and preserve vegetated wetlands.	Repair original earthen dikes, install metal box weir and pipe.	Provide 435 AAHUs.	$512,000 (Oct 93) $542,720 (Oct 95)
Pass a Loutre Crevasse, Louisiana	New Orleans District	Utilize available sediment to create emergent marsh.	Dredge crevasse channel and placed in unconfined area.	Converting approximately 80 acres, create 1,000 acres.	$2,858,000 (Oct 93) $3,029,480 (Oct 95)
West Belle Pass Headland Restoration, Louisiana	New Orleans District	Reduce encroachment and create wetlands.	Dredge, water control structure, plugs, and riprap.	Create, protect and restore about 474 acres; additional enhancement to 165 acres - total 639 acres.	$4,187,375 (Aug 92) $4,564,239 (Oct 95)

Project Name/District	District or Division	Primary Project Objectives and Goals	Major Engineering Features	Benefits and/or Outputs	Cost
Flood Control Projects with Environmental Features					
Black River, Missouri	Little Rock District	Reduce flood damages, preserve environmental resources.	Stream Obstruction Removal Guidelines (SORG).	$139,100 (Jul 90) average annual flood reduction benefits. $158,574 (Oct 95)	$355,600 (Jul 90) $405,384 (Oct 95)
Mayfield Creek, Kentucky	Memphis District	Reduce flood problems, protect fish and wildlife habitat.	Stream Obstruction Removal Guidelines (SORG).	Croplands and roads, fish and wildlife and recreation activities and land value.	$2,061,000 (Jan 90) $2,370,150 (Oct 95)
Jackson Hole, Wyoming	Walla Walla District	Reduce future economic losses, bank erosion, flooding and avulsion; restore fish and wildlife habitat.	Sediment redistribution, river training fences, rock spur dikes, wood spur dikes, boulder placement, root ball placement, channel restoration, flood plain habitat development, dike structures.	See page 149.	See page 148.
Rapid Creek, South Dakota	Omaha District	Improve trout habitat, create habitat capable of producing 0.5 catchable trout per angler hour.	Stone riprap, wing deflectors, rock ledge pools, boulder clusters, bank cover.	Increased fish productions.	$310,000 (Oct 84) $399,900 (Oct 95)
Sims Bayou, Texas	Galveston District	Achieve an environmentally sensitive solution that is also affordable, not achieve an affordable solution that minimizes environmental degradation and is ambivalent to ugliness.	Revised channel sections, elimination of cast-in-place concrete slopes, reduced thickness of Cellular Concrete Mats (CCM's), reduced extent of CCM's, open CCM's, addition of second in-channel berm, additional trees, adjustment of channel alignment, adjacent wetlands restoration, and incorporation of comprehensive recreational development plan.	$280,000,000 (Oct 90) Annual flood control benefit and $945,000 annually for recreation benefits. $316,400,000 (Oct 95)	$23,240,000 (Oct 90) $26,261,200 (Oct 95)

Project Name/District	District or Division	Primary Project Objectives and Goals	Major Engineering Features	Benefits and/or Outputs	Cost
South Platte River, Colorado	Omaha District	Compensate for fish and wildlife habitat loss caused by channelization.	Rock check dams, rock deflectors, boulder clusters, biostabilization, and revetments.	Ten-fold increase in catchable brown trout.	$300,000 (Oct 90) $339,000 (Oct 95)
Wildcat and San Pablo Creeks, California	Sacramento District	Reduce impacts of flood control project construction and restore lost habitat.	Sedimentation basin, cross-section shape, maintenance.	Project provided flood control benefits (unspecified benefits), the restoration benefits have fallen short of expectations. Some of the early vegetation plantings failed.	$28,800 (Oct 89) $33,408 (Oct 95)
Beneficial Uses of Dredge Material					
Bolivar Peninsula	Galveston District	Marsh creation	Temp. 10 x 4 ft sandbags , floating tire breakwater, plant rolls, erosion mats, & vegetation.	Short-term success - good; Long-term success - looking okay.	$2,500 (Oct 80) $3,925 (Oct 95)
Gaillard Island	Mobile District	Confined Disposal Facility	Riprap, planting behind floating tire breakwaters, plant rolls, and erosion control matting.	Short-term - planted marsh mixed; colonized marsh very high; wildlife use excellent.	$1.25 per CY (Oct 80) $1.96 per CY (Oct 95)
Jetty Island Salt Marsh	Seattle District	Salt marsh and seagrass creation	Environmentally engineered protective berm, intertidal saltmarsh, dredge material and plantings.	Highly successful site. Island upland used for day visits with park rangers and nature tours. Much wildlife use.	$620,260 (Oct. 89) $719,502 (Oct 95)
Salt Pond #3	San Francisco District	Marsh Restoration Site	Dredge material and plantings.	Successful.	Costs cannot be verified.
Windmill Point	Norfolk District	Marsh Creation Site	Dredge material, temporary sand dike as breakwater, plantings.	Dike failed; successful shallow water habitat.	$1.00 per CY (Oct 74) $2.74 per CY (Oct 95)

CHAPTER II - SECTION 1135 PROJECTS

Section 1135 of the Water Resources Development Act of 1986 (WRDA '86), as amended, through 1992, refers to Project Modifications for Improvement of Environment. It is cited as:

(a) The Secretary is authorized to review the operation of water resources projects constructed by the Secretary to determine the need for modifications in the structures and operations of such projects for the purpose of improving the quality of the environment in the public interest.

(b) The Secretary is authorized to carry out a program for the purpose of making such modifications in the structures and operations of water resources projects constructed by the Secretary which the Secretary determines (1) are feasible and consistent with the authorized project purposes, and (2) will improve the quality of the environment in the public interest. The non-Federal share of the cost of any modifications carried out under this section shall be 25 percent. No modification shall be carried out under this section without specific authorization by Congress if the estimated cost exceeds $5,000,000.

(c) The Secretary shall coordinate any actions taken pursuant to this section with appropriate Federal, State, and local agencies.

(d) Beginning in 1992 and every 2 years thereafter, the Secretary shall transmit to Congress a report on the results of the review conducted under subsection (a) and on the program conducted under subsection (b).

(e) There is authorized to be appropriated not to exceed $25,000,000 to carry out this section.

Projects for fish and wildlife restoration involving modifications in the structures and operations of projects may be implemented under the authority of Section 1135(b) of WRDA '86, as amended. Funding for studies and implementation of Section 1135(b) projects is provided on a nationwide programmatic basis.

A number of studies have been completed under the Section 1135 authority and several of these studies will be described in this chapter. For each of the studies, a brief description of the location of the project, resource problems and the stated objectives will be discussed. Descriptions of the management measures will follow along with the outputs and the total cost estimate.

BOYER CHUTE RESTORATION PROJECT, NEBRASKA
Omaha District

Location: The Boyer Chute Restoration project is located along the right bank of the Missouri River approximately 5 miles upstream of Omaha, Nebraska. This Section 1135 project restored a chute by modifying river revetments and closure dikes. The dikes were built as a component of the Missouri Bank Stabilization and Navigation Project. A 15,000-foot-long chute was closed as a part of that project.

Resource Problems: Historically, the Missouri River was a wide, meandering river, moving freely from one side of the floodplain to the other. The width of the river from high bank to high bank was as much as two (2) miles in some locations. The area between the high banks consisted of islands, low-elevation sandbars, shallow slow-moving chutes, backwater areas, oxbow lakes, and a deeper main channel that allowed some navigation. Severe flooding would cause major channel realignments. The chutes and channels of the Missouri River provided many ecological functions, such as spawning and rearing habitat for many native riverine fish species. Some of these species are currently in jeopardy. The river also provided habitat for waterfowl in the Central Flyway. Now, due mainly to Corps channelization and flood control on the river, the amount of habitat providing cover and food along the Missouri River floodplain water has been greatly diminished. These functions have been lost due to channelization, bed degradation, sedimentation, and/or plant succession. The river bed degradation has decreased the water levels in the adjacent wetlands and chutes, leaving these areas dry and developing into terrestrial vegetation. Lateral river migration has been stopped, and no new chutes or wetlands are being formed. At Boyer Chute, channelization of the river for navigation had cut off this historic chute from the river, leading to its becoming filled with sediments and with encroaching vegetation.

Objective: The objective for this project is to restore and enhance aquatic and terrestrial habitat in Boyer Chute on the Missouri River.

Management Measures: Different widths of pilot channels in the chute were evaluated for flow capacity and average velocity to determine the stability of the chute channel. Chute inlet, outlet structures, and grade control structures were designed, and stone was sized for all structures. The following describes the various structural measures implemented in modification of Boyer Chute.

- Constructing a 180-foot-wide notch in the river revetment closure structure at the upstream end of the chute. This revetment was converted from a closure structure to a 180-foot-wide by 14-foot-deep notched weir (inlet structure) that will allow flows from the top five (5) feet of the river channel to re-enter the chute from the upstream end. This involved lowering the structure and adding a bottom layer of larger riprap as armor to prevent the chute from capturing the main channel. The weir is designed to be overtopped. The larger riprap is able to withstand the increased velocities.

- Excavating a 10-foot-wide pilot channel through the accumulated sediments, from the upstream end of the chute to the outlet of the chute with side slopes of 1 vertical (V) on 2 horizontal (H) and 1V on 3H.

- Lowering an existing closure structure near the downstream end of the chute. This chute closure was also capped with a layer of quarried stone large enough to withstand head cutting velocities.

- Replacing the existing culverted earth-filed road crossing , which was acting as a dam on the chute, with a 118-foot-long bridge meeting American Association of State Highway and Transportation Officials (AASHTO) standards. Bridge cost is based on a 15-ton minimum load design to accommodate existing farm operations.. Velocities under the bridge are no more than 6 feet-per-second during high flows, which should not displace major portions of the riprap on the abutments.

- Constructing one new stone bed stabilization structure located approximately 2,300 feet upstream from the bridge. This structure was designed to be submerged.

- Removing stone from the revetment at the downstream end of the chute to achieve a 200-foot-wide notch. This revetment would be lowered and capped with quarried stone to allow the chute to flow more freely into the river.

Other management measures for this modification were examined. One consideration was to dredge the Boyer Chute area as a backwater without restoring inflows. This measure alone would not meet the environmental goals of the project because it would not provide flowing water. One other consideration was to install a pumping station at the upstream end of the chute to provide a flow regime similar to the one proposed. The pumping station with pumps, housing, revetment reinforcement, and flood protection structures would cost considerably more than the proposed inlet structure and would have an estimated annual pumping costs of about $50,000 ($56,000). The channel excavation and control structure would still be needed.

Costs: The total cost of rehabilitating the chute was $2.3M Apr ‘93 Price Level (P.L.) ($2.4M). This includes contingencies, engineering and design, monitoring and evaluation after construction, and construction management costs. Some real estate costs were needed for this project which added approximately $454,500 ($509,040). The OMRR&R cost estimates were divided into two (2) classifications: 1) increased OMRR&R for the bank stabilization and navigation project which adds approximately $2,100 ($2,352) per year, and 2) OMRR&R for the restoration of the chute which ranges from $12,500 ($14,000) to $26,000 ($29,120) per year.

Outputs/Benefits: The primary benefits will accrue to aquatic resources and riverine wetlands. The expected benefits of this project include an increase in fish habitat. Approximately 40

acres of flowing water surface area would be gained, replacing about 15 acres of backwater wetland, 10 acres of mudflats, and 15 acres of young forest and wet meadows. During average navigation flows, an average chute depth of five (5) feet would provide aquatic habitat of about 160 acre-feet of flowing water to replace about 35 acre-feet of backwater wetland, for a net gain of about 125 acre-feet of added habitat. This would represent spawning area, brood habitat, resting areas, and feeding areas.

Already, studies at different times have found surprisingly large numbers of sturgeon, catfish, and gar, some juvenile sturgeon and gar, and very large specimen of catfish, in the restored chute.

Other direct benefits will accumulate to other riverine organisms such as mollusks and crustaceans. Fish predators, such as cormorants and herons, are benefiting. Tangible benefits result from recreation associated with the fish and wildlife improvements. These include hiking, primitive camping, picnicking, fishing, and canoeing.

CARLYLE LAKE, KASKASKIA RIVER, ILLINOIS
St. Louis District

Location: The Carlyle Lake Wildlife Management Area (CLWMA) is part of the Carlyle Lake project. It is located 50 miles east of St. Louis, Missouri. This multipurpose project was completed in 1970 and provides for flood control, water supply, recreation, fish and wildlife conservation, water quality, and navigation channel flow augmentation. The upper portions of the lake include approximately 15,750 acres of project land and water licensed to the Illinois Department of Natural Resources (IDNR). Within this 15,750 acres, 4,050 acres are managed as uplands habitat, 8,500 acres as flooded timber and open water habitat, and 3,200 acres as a reservoir sub-impoundment to ensure feeding and resting areas for migratory birds (especially waterfowl). The sub-impoundment includes levees and water control structures. The 3,200 acre CLWMA is divided by Hurricane Creek into two major sections. The section east of the creek includes Pool units 1 and 2, while Pool units 3 and 4 are west of the creek.

Resource Problems: In the past 25 years, IDNR has experienced numerous hydrological problems that have prevented this area from reaching its originally planned habitat potential. Dependable water manipulation has not been possible due to lake induced flooding, inadequate water removal capability and erosion of levees during flood overtopping. IDNR implemented improvements to remedy some of these problems including: 1) raising exterior levees, 2) installing exterior overflow weirs, 3) placing exterior culverts, and 4) increasing pump capacity. However, more resource problems existed, including:

- Insufficient water separation between Pool 2 subunits and the section's main ditch
- Insufficient drainage between Pool 2 subunits and main ditch
- Insufficient balancing of flows between Pool 1 subunits
- Silt pockets obstructing water transfer along main ditch
- Silt pockets and/or inadequate ditching along interior levee system
- Subunit separation inadequate to establish optimal pool elevations
- Pool subdivisions inadequate to achieve optimal pool depths for the CLWMA
- No protection of interior levees during overtopping from major flood events

Objectives: Subobjectives were determined, corresponding to the stated problems:

- Improve subunit/ditch separation
- Improve flow between subunits and main ditch
- Improve balancing of flows in Pool 1
- Remove sediment pockets along main ditch
- Remove sediment pockets and improve ditch system
- Improve subunit separation
- Subdivide selected pools
- Provide adequate flood protection to levees during major flood events

Management Measures: Management measures developed to address the subobjectives are shown in Table 2. No single measure was found that could address all project subobjectives. All of the management measures were effective in alleviating portions of the water control problem, thus, a mix of management measures were required and are currently under construction.

The plan identifies four (4) increments of water control improvements that could be applied at the project site. Each increment consists of a mix of the management measures. Each increment is functionally separable. However, to address all of the site's water control problems and objectives, all of the increments would need to be included.

The capacity for transferring water between pools can be increased by the installation of 24 new gated culverts through the interior levees. These new culverts would be fitted with sluice gates, and would allow for water flow control in either direction. Adding new culverts will allow for balancing flows within the system.

Costs played an important role in determining the design criteria of each of the management measures. For example, levee material would be taken as near to the construction area as possible to avoid double handling of material; the weirs were designed with a grid confinement system (grid fabric and crushed stone) as opposed to riprap stone to save on costs while maintaining the same effectiveness; borrow areas would serve as post-project drainage ditches at no additional costs; and the culverts are the smallest and least expensive type that can still be easily maintained.

Costs: The total cost of the recommended plan is $954,200 Oct. '92 P.L. ($1,040,177). IDNR will be responsible for operating and maintaining the gates, and maintaining the ditches, levees, and weirs and estimated that O&M would average $11,000 ($11,990) per year in addition to that O&M currently expended for the project.

Outputs/Benefits: The project modification will allow for control of water levels and improved wildlife management, including: increased habitat diversity, improved food production and food availability, and improved quality of resting areas. The project also will minimize the destructive habitat loss caused by overtopping during flood events. While not a direct output of the modification, an increase in tangible recreation benefits could occur as a result of improved habitat conditions. Intangible benefits to migratory birds will be immediate.

TABLE 2
CARLYLE LAKE, ILLINOIS
MANAGEMENT MEASURES, DESIGN CRITERIA AND DESIGN SPECIFICATIONS

MANAGEMENT MEASURES	DESIGN CRITERIA	DESIGN SPECIFICATIONS
Construct Main Ditch Levees	Must prevent unwanted water movement between main ditch and subunits.	Raising of low sections of levees along lower main ditch, adding height to upper main ditch levees to the extent that ditch clean out permits.
		Bring main ditch levee to a level grade of 451 NGVD (include two (2)-foot of freeboard above highest subunit pool elevation). This is to provide water separation between pools and between pools and the main ditch.
	Levee slope should be stabilized.	Slopes placed at 1V on 3H and then seeded to grasses.
	Obtain levee material in a cost-effective manner.	Material obtained by draglining adjacent old ditch, or by creating an adjacent new ditch as a borrow area.
	Levee crown must be sufficiently wide to accommodate one-way vehicle movement.	Minimal crown width of 10-feet recommended.
Construct Gravity Drains	Ensure that drains are sized to be used at full capacity at designated pool elevations.	Only two (2) to three (3) feet of water depth exists at most locations; therefore, 24 to 36-inch pipes would be used.
	Total pipe capacity should be consistent with the water delivery capacity of the site pumps.	
	For maximum utility, drains should be capable of moving water bidirectionally.	Pipe invert elevation kept the same at both ends of pipe.
	Erosion protection should be provided at pipe entrance and exit.	Stone riprap surrounding pipe entrance.
	Provide a means of water control at each pipe.	Sluice gates appr. for given pipe size.
	Provide a means for determining need to adjust water levels within a specific subunit pool.	Provide staff gages for each pool.
	Ensure utility and functionality of all existing drains.	Remove obsolete units and replace nonfunctional units, as required.

TABLE 2
CARLYLE LAKE, ILLINOIS
MANAGEMENT MEASURES, DESIGN CRITERIA AND DESIGN SPECIFICATIONS

MANAGEMENT MEASURES	DESIGN CRITERIA	DESIGN SPECIFICATIONS
Excavate Ditches	Configure levee borrow areas to function in water drainage.	Borrow ditches to be excavated to a maximum of three (3) feet in depth (takes public safety into account), need for additional material to be met by varying the width of the excavated ditch.
	Clean ditches to an optimal depth, and dispose of material in most cost-effective manner.	Excavate ditches by dragline to a maximum depth of three (3) feet, and dispose of material directly onto adjacent levees.
	Protect levee disposal area from erosion.	Disposal sections to be subsequently mulched and seeded.
Construct Subunit Levees	Must prevent unwanted water movement between subunit pools compatible with proposed pool elevations.	Raising of low sections of levees throughout interior system, add cross-levees to subdivide pools.
	Levees should be stabilized.	Slopes placed at 1V on 3H and then seeded
	Obtain levee material in a cost-effective manner.	Material obtained by draglining a borrow ditch immediately adjacent to levee segment under construction.
	Levee crown sufficiently wide to permit one-way vehicle movement.	Minimal crown width of 10-feet recommended.
Construct Overflow Weirs	Weir should be capable of withstanding a maximum head differential of one (1) foot.	Weirs should be 50 feet wide, weir crest of 0.5 foot above normal interior pool and 1.5 feet below levee crest elevation, weir to be surfaced with geogrid fabric filled with crushed stone extending to levee toe on both sides of weir; total of 17 new weirs installed.
	Weir should accommodate vehicle traffic transition between weir and levee crests.	Levee to weir slopes 1V on 10H to provide a gentle transition between weir and levee crests, geogrid/stone weir surface will support traffic.
Back flooding	Project should be operated so as to minimize potential damages from overtopping.	When a flood threatens unit, all four (4) pumps should be operated and gravity drains opened to back flood area prior to exterior levee overtopping.

FERN RIDGE LAKE, LONG TOM RIVER, OREGON
Portland District

Location: Fern Ridge Lake is located in Lane County, Oregon, about six (6) miles west of the Eugene/Springfield, Oregon, metropolitan area. The lake lies at the upper (southern) end of the Willamette Valley near the east slope of the Coast Range. Fern Ridge Dam crosses the Long Tom River 23.6 miles upstream from its confluence with the Willamette River. The Long Tom River drains an area of 275 square miles above the dam. The Fisher Butte Management Unit is a discrete 1,128 acre management unit in the southeastern corner of Fern Ridge Lake Project. The modification project is located within the Fisher Butte Management Unit and comprises approximately 10 percent of that unit.

Resource Problems: The entire Willamette Valley of Oregon has experienced a significant reduction in the quantity and quality of waterfowl habitat due to agricultural conversion and urban/industrial development. The majority of the remaining waterfowl habitat in the Willamette Valley occurs in concentrated areas. Concentration of waterfowl in only a few key areas can have negative impacts. Waterfowl disease outbreaks are often related to concentrating large numbers of waterfowl in small areas.

Objectives/Goals: Objectives/goals for this project are:

- Aid restoration of wintering waterfowl habitat quantity and quality
- Increase winter survival and thereby increase the breeding and overall waterfowl population
- Lessen disease transmission potential
- Increase private sector development and/or retention of wetlands
- Provide for a more evenly distributed waterfowl in the Willamette Valley

Management Measures: The proposed plan includes:

- Creation of three (3) impoundments, comprising 115 acres, by constructing levees and ditches
- Installation of an irrigation water supply pump with an eight (8)-inch diameter water supply pipeline
- Construction of overflow spillways
- Installation of drainage culverts with positive closure gates

Table 3 describes the management measures used in this project.

TABLE 3
FERN RIDGE LAKE, OREGON
DESCRIPTIONS OF MANAGEMENT MEASURES

MANAGEMENT MEASURES	DESCRIPTIONS
Mobilization, Demobilization, and Prepatory Work	Equipment obtained from a distance of 10 to 20 miles from the site.
Common Excavation	Approximately 32,000 cubic yards of materials to form the required channels and canals. The materials excavated would primarily consist of a stiff clay which rapidly loses strength when wet and/or remolded. Swell factor of 25 percent is recommended.
Levee Embankment	Approximately 25,000 cubic yards of excavation materials for shaping and compacting to form the levee embankments. The SOW for compaction is limited to that achieved by three (3) passes of bull dozers. An average shrinkage and loss factor of 35 percent is recommended as the conversion from bank to compacted yardage.
Spillway Rock	Approximately 470 cubic yards of six (6)-inch-minus rock delivered from a source 15 miles from job site and spreading and compacting of rock in one (1)-foot lifts by dozer.
24-Inch Diameter Corrugated Metal Pipe (CMP)	240 linear feet and installation of nine (9) 24-inch CMP's across the main levee and cross levees, including trenching, pipe placement and backfilling.
24-Inch Diameter Sluice Gates	Nine (9) sluice gates on the 24-inch CMP. Sluice gates will be ARMCO Model 150 or equal.
42-Inch CMP	75 linear feet of the 42-inch CMP.
42-Inch Diameter Sluice Gate	Sluice gate on the 42-inch CMP. The sluice gate will be ARMCO Model 150 or equal.
42-Inch CMP Embankment	Installation of this feature was modified per BLM field suggestion. Site of ditch plug and 42" CMP was on curve. BLM recommended construction placement of the 42" CMP on the inside of the curve and in dry ground. Thus, the CMP site was excavated in dry ground. Sufficient space was left at either end of the CMP site for the existing soil to serve as cofferdam. A sump pump was used to remove any seepage. Once the CMP was in place, the soil at either end was removed to provide connection to drainage ditch. The soil excavated for the CMP was then used to form the ditch plug. Corps avoided working in water which is sloppy at best, did not have a cofferdam to remove, and saved several days of construction time plus dollars.
Irrigation Pump	500-gpm centrifugal pump.
8-Inch Plastic Pipe	1,350 linear feet of pipe.
Treated Timber Posts	Four (4) 6x6x14 foot & 16 6x6x6 foot posts in the 42-inch CMP embankment.
Electrical, Pump Hook-up	One (1) pump.

Each spring, the impoundments would be drained and planted to cereal grains and/or managed for moist soil plant communities to provide food for waterfowl. The crops would be irrigated during the summer; in fall and winter the impoundments would be flooded to improve waterfowl use of forage crops. Management for moist soil plant communities would entail periodic shallow flooding of impoundments during the growing season and prolonged flooding during late fall, winter and early spring.

Costs: Initial cost savings associated with this project were obtained by reducing the number of impoundments and refining design elements. Utilizing Bureau of Land Management (BLM) work forces to construct the project modification was recommended as a construction option on a cost reimbursable basis. Using BLM provides a significantly less expensive project by:

- Eliminating profit from the estimate
- Substantially reducing the Planning Engineering and Design (30 account)
- Eliminating construction management (31 account)
- Utilizing lower BLM labor and equipment rates

The final project cost was $210,664.50 which is substantially lower than that originally estimated for BLM to construct the project (e.g., $298,604 Jun '92 P.L. ($326,194)). Working with BLM has provided the Portland District COE on site management by their staff, easy coordination, and the flexibility to make changes on site during the course of a simple discussion between both parties. The Corps was able to return money to their local sponsor on this project.

Outputs/Benefits: The principal nonmonetary benefit would accrue from the projected increase of 200,000 Waterfowl Use Days (WUD) at Fern Ridge Lake. Other nonmonetary benefits would be provided for other species. Resident and wintering bald eagles and migrant/wintering peregrine falcons are expected to benefit from the increase in wintering waterfowl associated with management of the Fisher Butte waterfowl impoundments. A greater prey base capable of supporting additional wintering eagles, in addition to providing more stable prey base for the resident pair, is an expected by-product of the proposed action. This would aid in recovery goals set forth in the Pacific States Recovery Plan for bald eagles. Peregrine falcon recovery efforts would be aided in a similar manner. Other raptors, including red-tailed hawks, rough-legged hawks, and northern harriers make substantial use of the waterfowl impoundments for foraging.

Economic benefits are based on the monetary value of the net change in user days resulting from the improvements. The net increase in waterfowl hunter user days attributable to the proposed development is estimated to be between 95 and 286 hunter days annually. With a value of $15.41 ($16.80) per user day, the benefit associated with increased hunter use days ranges between $1,464 ($1,596) and $4,407 ($4,804) annually. The net increase in primary nonconsumptive user days attributed to the proposed development is estimated to be between 1,500 and 3,000 user days. With

a value of $17.75 per user day, the benefit associated with increased primary nonconsumptive user days ranges between $26,625 ($29,021) and $53,250 ($58,042).

Annual monetary benefits range from totals of $28,089 ($30,617) to $57,657 (62,846) with a project life of 50 years. Annual monetary costs total $21,553 (23,493). The benefit to cost ratio for the monetary benefits and costs range from 1.30-2.68 to 1.

GALILEE SALT MARSH RESTORATION, NARRAGANSETT, RHODE ISLAND
New England Division

Location: This Section 1135 Project is part of an overall effort to restore salt marsh in the Galilee Bird Sanctuary under the Coastal America partnership. Coastal America is a cooperative initiative among Federal, state and local agencies, the private sector, and citizens dedicated to improving the quality of the environment along the Nation's coastline. The sanctuary is also listed as a priority focus under the Atlantic Coast Joint Venture of the North American Waterfowl Management Plan.

The restoration area lies within about one-half of a 128 acre bird sanctuary, located near Point Judith in the town of Narragansett, Rhode Island. This portion of the sanctuary was affected by previous Federal dredged material disposal actions. The greater part of this area varies in elevation from about one (1) feet National Geodetic Vertical Datum (NGVD) to four (4) feet NGVD. The southern perimeter is bordered by residential properties and Sand Hill Cove Road. The western perimeter is bordered by the Galilee Connector road. An existing disposal site occupies about 10 acres of land on the northeast corner of the Connector road. The top elevation of this disposal site varies from about 10 feet NGVD to 20 feet NGVD. The northern perimeter is bordered by the Galilee Escape Road. The eastern perimeter is approximately bordered by the remnants of a causeway, formerly used as a means to access Great Island.

Resource Problems: The Galilee Bird Sanctuary was acquired for use as a bird sanctuary by the Rhode Island Division of Fish, Wildlife and Estuarine Resources (RIDFWER), Department of Environmental Management by a state executive order. Historically, the 128-acre site was mostly salt marsh. However, the disposal and placement of fill material from navigation and road construction projects significantly restricted tidal flow to the marsh. Today, the site contains a mixture of salt marsh and former salt marsh dominated by common reed (Phragmites australis). Today, less than 20 acres of salt marsh and open water exist in the sanctuary, about nine (9) acres of which is vegetated salt marsh supported by tidal flow. Up to about one-half of the sanctuary qualifies for salt marsh restoration under Section 1135 Authority. However, the maximum allowable water level governed by flood risks to neighboring properties and the presence of two disposal sites diminish the area within this portion of the sanctuary which could otherwise be restored to salt marsh. Areas in the sanctuary elevated above the maximum water level cannot be restored. To prevent additional flood risks of bordering properties, the allowable tide level is not to exceed 2.9 feet NGVD in the sanctuary.

During a 1954 hurricane, residents of Great Island and Galilee were trapped by the extreme flooding of Sand Hill Cove Road. The Rhode Island Division of Public Works constructed the Galilee Escape Road in 1956. Construction of this road completely fragmented the marsh and, in the process, filled about seven (7) acres of salt marsh. Salt water exchange in the fragmented marsh was limited to flow through a 30-inch culvert, installed primarily for interior drainage purposes.

The area south of the Escape Road has been affected by restrictions in tidal flow and filling with dredged material. A complex system of natural feeder channels and man-made ditches once fed an extensive salt marsh in the sanctuary. However, several disposal and filling activities including dredged material disposal from navigation improvements in Point Judith Pond and construction of the Escape Road diminished the conveyance of saltwater. As a result of these activities, coastal wetland habitat for migratory waterfowl, wading birds and shorebirds, and finfish and shellfish was significantly reduced and/or eliminated.

In 1984, RIDFWER, in cooperation with the Rhode Island Department of Transportation, attempted to improve tidal flushing to the sanctuary by installing an additional culvert adjacent to the existing culvert located at the east end of the Escape Road. However, this effort had little effect on restoring salt water exchange to the degraded marsh.

Management Measures Considered

Alternative 1 - No Action. Under this alternative, restoration of salt marsh in the areas impaired by the Federal Government would not be realized. In addition, engineering and environmental evaluations and construction management would need to be done by others.

Alternative 2 - Single Channel Restoration. The components include:

- Excavating a former main channel north of the sanctuary between Bluff Hill Cove and the Escape Road
- Constructing twin culverts and flow control gates
- Excavating former natural channels within the sanctuary
- Disposing of all excavated material within the site

The investment cost, annual operations and maintenance cost, and replacement cost of this alternative are estimated to be $1,576,600 ($1,671,196), $10,000 ($10,600), and $1,530 ($1,622), respectively. Total annual charges are about $154,100 ($163,346) which is the sum of the interest and amortization of investment cost, O&M cost, and replacement cost. O&M cost is based on estimated periodic equipment inspection and stop log operation. The project life is 50 years, and replacement cost is based on the cost of replacing self regulating tide gates after 25 years.

Outputs/Benefit: This alternative would restore about 34 acres of salt marsh habitat. The 34 acres would consist of about 24 acres of fully restored and eight (8) acres of partially restored salt marsh and about two (2) acres of intertidal habitat within the channels.

Alternative 3: Double Channel Restoration. Components of this alternative are:

- Excavating two former main channels north of the sanctuary between Bluff Hill Cove and the Escape Road
- Constructing a culvert with flow control gates at each channel

- Excavating former natural channels within the sanctuary
- Disposing all excavated material within the site

The investment cost, annual operations and maintenance cost, and replacement cost of this alternative are estimated to be $1,910,400 ($2,025,024), $10,000 ($10,600), and $1,530 ($1,622), respectively. The total annual charges are $167,600 (177,656).

Outputs/Benefits: The outputs for this alternative are the same as for Alternative 2.

Alternative 4: Single Channel Restoration and Installation of Pumps. Components of this alternative include:

- Excavating a former main channel north of the sanctuary between Bluff Hill Cove and the Escape Road
- Constructing a pumphouse and installing pumping equipment
- Excavating former natural channels within the sanctuary
- Disposing all excavated material within the site

The investment cost of this alternative is approximately $4,455,000 ($4,722,300,). Annual operation and maintenance cost of this alternative is estimated to be in excess of $300,000 ($318,000). The total annual charges are in excess of $660,000 ($699,600). Operation and maintenance cost is based on operator and energy costs. Periodic inspection and replacement costs have not been evaluated for this alternative because the high investment cost already shows that this alternative is uneconomical. Project life was determined to be 50 years.

Outputs/Benefit: The outputs for this alternative are about the same as for Alternatives 2 and 3.

Table 4 describes each of the three (3) alternatives, excluding the No Action Plan, in greater detail. Alternative 2 is the plan that is now being implemented.

TABLE 4
GALILEE SALT MARSH RESTORATION, NARRAGANSETT, RHODE ISLAND
ALTERNATIVES DESCRIBED

ALTERNATIVE	MANAGEMENT MEASURE	DETAILED DESCRIPTION
Alternative 2 - Single Channel Restoration	Excavating a former main channel north of the sanctuary between Bluff Hill Cove and the Escape Road and excavating former natural channels within the sanctuary	Channels are to be excavated to the north and south of the culverts. To the north, a single channel of about 40 ft. in bottom width (elevation -1.0 feet NGVD) is to be excavated from Bluff Hill Cove to the culvert entrance chamber. The length of this channel is about 500 ft., with side slopes of 1V to 1H. To the south, channels will vary in bottom elevation and bottom width. These channels consist of a main channel leading from the culverts with side slopes of 1V to 3H and three (3) feeder channels with side slopes of 1V to 1H. The bottom width of the main channel south of the Escape Road varies from a maximum of 35 ft. at the culverts to a minimum of 15 ft. at 1,100 ft. south of the culverts. The invert of the main channel varies from -0.7 ft. NGVD at the culverts to -0.13 ft. NGVD at 1,100 ft. south of the culverts. Maximum bottom widths of the secondary channel and three (3) feeder channels are 10 ft.
	Constructing twin culverts	Hydraulic sizing criteria for culverts require an opening of 6 ft. by 20 ft. for hydraulic conveyance to provide saltwater interchange to the impaired area. To meet this requirement, two (2) 6 ft. by 10 ft. culverts will provide the necessary equivalent hydraulic opening proposed. Each culvert will be about 150 ft. in length. Culvert construction is based on open excavation. Two (2) ft. of crushed stone fill will be used for bedding beneath the culverts. At the south end of the culverts, a head wall will be constructed and stone protection will be placed at both ends to prevent erosion to the bottom of the channels. At the north end of the culverts, entrance transition consisting of two (2) side walls and an end wall is designed to house flow control gates.
	Constructing flow control gates	Flow control gates will consist of self regulating tide gates with a stop log system as back up. Self regulating tide gates are “two-way” tide gates which open and close automatically. Gate movement is governed by a pre-set float actuated water control valve. Each 6-ft. by 10-ft. culvert is designed to have one (1) 6 ft. by 4.5 ft. self-regulating gate because this is about the largest size gate currently manufactured. Automatic operation occurs over the full range of tide conditions. These gates will be adjusted in the field to ensure that flood risks to adjacent properties will not be increased above those which currently exist. Stop logs will provide a backup for assured gate closure during flood events. Operating procedures for deployment of the backup stop logs will be established, should the self regulating tide gates fail to provide complete closure during severe coastal storms.
	Disposing all excavated material within the site	A designated disposal site for excavated material will be located on the northwest corner of sanctuary. Site was designated by RIDFWER and agreed upon by other Coastal America participants. Upper limit of material which can be disposed in this 9.7-ac. site is about 52,000 cu. yds. Maximum elevation of disposal material is 9 ft. NGVD with slope of 1V on 6H. Vegetation will be planted for stabilization and erosion prevention. Total volume of excavated material resulting from recommended alternative, including grading material from unused portion of disposal site, is estimated to be about 17,500 cu. yds. About 6.5 acres of the 9.5 acres of disposal site will be used.
ALTERNATIVE	**MANAGEMENT MEASURE**	**DETAILED DESCRIPTION**

TABLE 4
GALILEE SALT MARSH RESTORATION, NARRAGANSETT, RHODE ISLAND
ALTERNATIVES DESCRIBED

Alternative 3 - Double Channel Restoration	Excavating two (2) former main channels north of the sanctuary between Bluff Hill Cover and the Escape Road and excavating former natural channels within the sanctuary	The bottom width of each of the main channels north of the Escape Road is 20 ft. These channels have a trapezoidal cross section with side slopes of 1V to 1H. The invert of each of the main channels is -3.0 ft. NGVD and remains constant for its entire length. Channels south of the Escape Road consist of main channels leading from the box culverts, a secondary channel, and 4 feeder channels. The 2 main channels would join south of the Escape Road. The bottom width of each channel south of the Escape Road would be about 17 ft. Once the channels join, the bottom width of the single channel would vary from a maximum of 35 ft. to a minimum of 15 ft., 2,000 ft. south of the culverts. Remaining design features are the same as for Alternative 2.
	Constructing a culvert with flow control gates at each channel	One culvert is located in the same location as described in Alternative 2 and the other culvert is located eastward along the Escape Road near the site of another former channel. The sizes of the box culverts and invert elevations are the same as described in Alternative 2. Culverts and channels are sized in a manner to supply an equivalent amount of salt water into the affected areas as would be achieved with Alternative 2. Although a hydraulic analysis was not performed for this alternative, this alternative is predicated on the conditions that 1) the combined flow through the separate 6-ft. by 10-ft. culverts would be equivalent to the combined flow through the adjacent twin culverts described in Alternative 2, and 2) that the total flow would flood the same area.
	Disposing all excavated mat. within the site	Same as Alternative 2.
Alternative 4 - Single Channel and Install Pumps	Excavate former main channel north of sanctuary between Bluff Hill Cove and Escape Road and excavate former natural channels within sanctuary	Channel work similar to that of Alternative 2. Culverts beneath the Escape Road and flow control gates, however, would be replaced by the pumphouse, pumping equipment and piping beneath the Escape Road.
	Constructing a pumphouse and pumping equipment	To supply near equivalent amount of salt water into affected area as achieved with Alternatives 2 and 3. Pumps operated in manner to supply water to sanctuary during an incoming tide and discharge water during outgoing tide.
	Disposing all excavated material within the site	Located in sanctuary northwest corner of site. Balance of designated disposal area graded to create high marsh zone.

HOMME DAM/LAKE, NORTH DAKOTA
St. Paul District

Location: The Homme Dam/Lake is located in the northeastern section of North Dakota (Walsh County), about 60 miles northwest of Grand Forks, North Dakota, and about six (6) miles west of Park River, North Dakota. Homme Dam is on the south branch of the Park River approximately 62 miles upstream from where the main stem of the Park River joins the Red River of the North.

Resource Problems: The Corps of Engineers maintains approximately 400 acres for project operations at Homme Lake. Terrestrial habitat (forests, grasslands, and willow) make up about 190 acres, with the remaining area consisting of aquatic habitat. The main part of Homme Lake is deep, open water that is heavily used for recreational boating. This open water portion is 180 acres with scattered cattail growths and little submergent vegetation. A five (5)-acre dense cattail is located in the upper portion of the lake. Another feature of note in the upper end of the lake is an oxbow channel cut off from the main flow of the Park River.

Habitat conditions for waterfowl at Homme Lake are presently deficient. A small percentage of the area has aquatic vegetation, most of which is limited to the upper end of the lake. Homme Lake lacks habitat interspersion because there is no aquatic vegetation in the lower end of the lake. Ninety-five percent of Homme Lake is deep, open, and at times used intensely for recreation. The surrounding area is heavily cultivated, and waterfowl nesting sites are limited. An oxbow channel is separated from the reservoir by a collapsed small culvert under an unimproved road. Only minor flows can be passed through this culvert, and no water level controls are possible. Habitat is expected to degrade in the oxbow because of stagnant water conditions.

Objectives: To enhance the habitat value of the existing wetlands in the project area, to increase the nesting habitat for wildlife, and to increase the overall value of Homme Lake and the surrounding area for fish and wildlife.

Management Measures: The chosen management measures for this project are described in Table 5.

Costs: The cost of the project is estimated to be $36,600 Mar. ‘91 P.L. ($40,488). After construction, the operation and maintenance of the project features would be the responsibility of the North Dakota Game and Fish Department. They would be responsible for monitoring the waterfowl nesting structures and for manipulating the stoplog standpipe structure every five (5) to seven (7) years to stimulate the growth of the aquatic vegetation. It is estimated that operation and maintenance activities would average $100 ($112) per year.

TABLE 5
HOMME LAKE, NORTH DAKOTA
MANAGEMENT MEASURES AND DESCRIPTIONS

MANAGEMENT MEASURES	DESCRIPTIONS
Potholes/Waterfowl Pair Ponds	Created in the cattail stands. Prior to the placement of the culverts, four 1,500-sq.-ft. waterfowl pair ponds would be created in a shallow cattail stand through the use of explosives.
Nesting Structures/Culverts	Placed in a shallow cattail bay . Seven 48-inch-diameter culverts would be installed within the cattail areas in the upper end of the lake. Placed at least 150 feet from the shoreline and spaced at least 300 feet apart. Height would be three to four feet above the normal water surface. Once firmly placed, filled with topsoil to the top, and mulched and seeded. These vertical culverts planted with nesting cover would provide nesting sites for ducks and geese secure from predators.
Culvert and Half-round Standpipe/Stoplog Control Structure	Three-foot-diameter culvert with a six-foot-diameter half-round standpipe/stoplog control structure in an oxbow channel. Temporarily breach the road and install the structure. The fill material would be replaced in order to create a dike.

Outputs/Benefits: Installing the culvert and control structure would make possible periodic drawdowns and other water level manipulations in the oxbow. Occasional drawdowns would consolidate bottom sediment, provide seed germination, and release important nutrients back into the soil through oxidation. This would improve vegetation substrate with a concurrent increase in aquatic invertebrates. The combination of these factors would increase breeding and nesting waterfowl habitat. Wildlife that would benefit from improved habitat conditions in the project area include migrating waterfowl, aquatic and terrestrial furbearers, songbirds, amphibians, reptiles, and raptors. The nesting culverts would improve the distribution of secure waterfowl nesting sites in the cattail stand. The creation of potholes would improve the distribution of open water areas in the dense, unbroken cattail stand, and would provide waterfowl courtship and brood rearing habitat.

The project is located within the Prairie Pothole Joint Venture area, one of the priority initiatives of the North American Waterfowl Management Plan. The proposed action would contribute to meeting the stated goal of the Prairie Pothole Joint Venture to protect and enhance 1.1 million acres of waterfowl habitat on public and private land in the prairie pothole region.

Other Management Measures - Three (3) other management measures and the no action alternative were identified as follows:

- **No Action** - This alternative would not fulfill the objectives of improving habitat conditions in the project area.

- **Construction of islands for waterfowl nesting in an open water area** of Homme Lake would, in all likelihood, require the importation of material for island fill to provide a more

stable island in these more unsheltered areas of the lake. Importation of material from an outside source into a reservoir designated for water supply was not considered consistent with the project purpose.

- **Formation of small pools** within the main channel of the river immediately upstream of the main reservoir through the construction of low-lying rock weirs was considered to increase waterfowl habitat. Closer inspection of the river in this area indicated that beaver activity was backing up water in a sufficient number of areas such that the creation of additional pools was not considered necessary.

- **Construction of meandered openings** was considered within the southwestern bay of the reservoir. They would consist of a zigzag pattern and channel lengths designed to provide a feeling of isolation between waterfowl pairs through the drawback of sight lines. Within the five (5) acre cattail area, there was room to dredge two (2) channels, creating 1.2 acres of open water. The dredged material would be sidecast to create 18 waterfowl nesting islands. This alternative was rejected because of high costs compared to the gain in habitat benefits. Another reason for rejection was that predators and nesting waterfowl are both attracted to these nesting islands.

HOUMA NAVIGATION CANAL, LOUISIANA - MARSH CREATION AT WINE ISLAND SHOALS
New Orleans District

Location: The Houma Navigation Canal provides a channel, approximately 40.5 miles long with a 15-foot depth and 150-foot width, from the Gulf Intercoastal Waterway (GIWW) to the Gulf of Mexico. It provides navigable access from the Gulf of Mexico to the GIWW, the Port of Houma, and other small ports along the canal and adjacent bayous.

Resource Problems: The Wine Island shoals are remnants of Wine Island, one of a discontinuous chain of barrier islands formed in the Terrebonne Bay hydrologic basin on the abandoned Lafourche delta periphery. Between 1956 and 1978, shoreline erosion rates in the Terrebonne Bay hydrologic unit averaged about 36 feet per year.

Barrier islands in the chain are experiencing a net retreat while moving laterally along the coast, eroding on the eastern ends and increasing on the western ends. Local interests are attempting to restore barrier islands on either side of the Wine Island shoals in an effort to maintain these important buffers between the Gulf of Mexico and the coastal marshes and communities. The barrier islands absorb and dissipate wave energy and reduce flooding effects from storm tides generated in the gulf.

Barrier islands provide habitat for numerous migratory and nonmigratory bird species. Roosting, loafing, and foraging habitat associated with the barrier islands has decreased with the erosion of these islands. Some migratory bird species are extremely dependent on these areas for resting and foraging prior to trans gulf migrations. Recreational activities are also associated with barrier islands, including fishing, camping, and nature study.

Management Measures: The Wine Islands Shoal, located approximately 1.7 miles west of River Mile 0.0 of the Houma Navigation Canal, is recommended as a dredged material disposal site rather than the ocean disposal site normally used. Ocean dumping is considered less beneficial use of dredged material when compared to the marsh creation opportunity at Wine Island. The creation of marsh with dredged material during routine maintenance of the waterway would restore a portion of Wine Island and contribute to local efforts to protect coastal marshes and communities through restoration of barrier islands, as well as enhancing fish and wildlife resources.

Louisiana Department of Natural Resources (LDNR), the local sponsor, commissioned the design of a rock dike to aid in retention of the pumped material and to provide erosion control against normal wave action. Enclosing the disposal area will encourage future dredge disposals at the site to maintain the created wetland. LDNR will contract the construction of the retention/erosion control structure.

Approximately 6,525 linear feet of dike will enclose a 48.4-acre shallow, open water area on the central Wine Island Shoal. The rock will be barged to the site using existing channels. After deposition of the dredged material is complete, approximately 40 acres of exposed surface will be vegetated by LDNR.

Costs: The cost for construction of the retention/erosion control structure is $607,000 Jul. '93 P.L. ($644,817). Currently, dredge material is removed with a hydraulic cutterhead dredge and placed in an ocean disposal site 1,000 feet west of the channel centerline. The cost of proceeding using that same method was compared to pumping about 600,000 cubic yards of dredged material to the Wine Island disposal area. The increased cost associated with the proposed project modification is estimated to be $400,000 ($424,000). The additional cost can be attributed to the following: 1) the cost to place the additional length of disposal line, 2) increased down time of the dredge due to extending the pipeline, and 3) decreased production rates associated with longer pumping distance. Of the total project cost of $1,000,000 ($1,060,000), LDNR has agreed to provide $607,000 ($644,817), about 60 percent, and the Federal share will be $400,000 ($424,000), about 40 percent. A deviation of cost-sharing (increase from local share) from a typical Section 1135 project.

Outputs/Benefits: Barrier islands afford protection from hurricane and storm surges and enhance fish and wildlife resources in the area. Using the Wine Island disposal site provides an opportunity to restore one of these vital barrier islands. The barrier islands absorb and dissipate wave energy and reduce flooding effects of the storm tides generated in the gulf.

Positive impacts to fishery species from the restoration of marsh would result from an increase in marsh/water interface, an increase in detrital food material, and the slowing of the conversion of shallow water habitat to less productive deeper water areas. This would help maintain the current fishery productivity rate of the wetlands.

The 40 acres created by this project would generate annually a total of about $15,500 ($16,430) in commercial fisheries output beginning in the third year of the five year project life. An additional 55 man-days of recreation valued at $800 ($848) would also be realized. A total, $16,300 ($17,278) per year, represents an average annual benefit of $9,000 ($9,540) when amortized. Barrier islands afford protection to coastal marshes against hurricane and storm surges by absorbing wave energy. In addition to creating 40 acres of wetlands, the modification will also aid in the protection of existing marshes.

Migratory waterfowl and other game birds make extensive use of the coastal marshes during the winter months. Other waterfowl and migratory bird species that may not over-winter are extremely dependent on these areas for resting and foraging prior to trans gulf migrations. In addition, many species of nongame birds occur here.

The marshes also support a number of valuable furbearers and game mammals, as well as various species of small mammals. They provide unique habitats for nonconsumptive outdoor recreation such as birdwatching and nature study. Further, the coastal marshes function as an essential element in the preservation of the unique history and cultural heritage of those who work and live in coastal Louisiana.

LAGUNA MADRE SEAGRASS PROJECT, TEXAS
Galveston District

Location: The Laguna Madre Seagrass project is located near Port Isabel, Cameron County, Texas, which is situated at the southern tip of Texas.

Resource Problems: Several man-made projects, such as the Gulf Intercoastal Waterway (GIWW) and other navigation channels, several flood control/irrigation-drainage networks on the mainland, and an artificial pass to the Gulf of Mexico, have altered the salinity, circulation, and turbidity patterns in the Laguna Madre. As a result, seagrass cover and composition have changed considerably from historic conditions, meaning the loss of seagrass coverage. Measurements, over the last 20 years in the lower Laguna Madre, indicate a 60 percent decrease in coverage by the dominant seagrass (shoalgrass, Halodule wrightii) and a 280 percent increase in the amount of barren bay bottom.

Current dredge disposal methods place the sands, silts, and clays that collect in the channel in open-bay disposal areas along the GIWW. Over the years, some of these disposal areas have been built sufficiently to allow seagrass to invade the shallowest parts and occasionally to establish extensive beds. These seagrass beds create habitat diversity and attract many different aquatic species to the area that would not ordinarily be found on the barren bay bottoms that previously occurred there.

Objective: The objective is to determine whether transplanting seagrass onto freshly deposited dredged material will increase the rate of recovery of seagrass habitat and associated fish and wildlife resources in a disposal area.

Management Measures: Two construction alternatives and a No Action alternative were considered. The No Action alternative was eliminated, because it would not demonstrate the effectiveness of transplanting seagrass into a disposal area, and one of the alternatives was determined to be ineffective.

Alternative 1 - Transplant Seagrass out of Disposal Areas - Initially this alternative was designed to restore full disposal use to some open-bay areas in the Laguna Madre that the COE had partially closed to protect the seagrass that had colonized in some of the shallower areas. By removing most of the seagrass in these disposal areas and transplanting it to nearby unvegetated bay bottom, it was hoped that the seagrass resource could be saved, and full use of the disposal areas could be restored. It became apparent that there were problems with this alternative. The transplanted seagrass would not survive on nearby undisturbed bare bay bottom, probably due to insufficient light penetration at those depths to sustain the plants. Resource agency biologists suggested a different approach which is Alternative 2.

Alternative 2 - Transplant Seagrass into Disposal Areas - This alternative was designed to remedy the shortcomings of the first alternative and meet the planning objectives. With help from the National Marine Fisheries Service (NMFS) biologists, the seagrass transplanting procedure was altered to transplant seagrass from nearby naturally occurring sources, onto freshly deposited dredged material, in open-bay disposal areas. The biologists thought this would shorten the recovery time between dredging cycles that would be needed for seagrass to colonize newly created bare areas in the disposal areas. This would help restore the aquatic environment, by increasing the value of the bottom for many fishery species and other estuarine animals.

The proposed alternative, Alternative 2, will transplant shoalgrass (Halodule wrightii) into two (2) open-bay disposal areas near Port Isabel, Texas. When fresh dredged material is deposited, shoalgrass will be planted on 1-m (3.28 feet) centers on 50m x 50m plots (0.62 acres) at two elevations in each of three (3) sites. A total of 3.7 acres will be transplanted seagrass. Unvegetated control plots at the same elevations will be established in adjacent areas of the disposal sites, on both newly deposited dredged material and on older dredged material sites, to monitor natural recovery in the seagrass and aquatic community. A nearby natural seagrass bed will also be monitored to compare with the test results from the demonstration sites. Seagrass, sediment, and infaunal and epifaunal samples will be taken at each of the sites in the spring, summer, and fall along with continuous measurements of light (for extension coefficients) and water level.

The COE will be responsible for the basic design and management of the project, coordination with other agencies, and report preparation. The COE will contract with the NMFS to survey, monitor, and collect, and analyze the data on conditions at demonstration and control plots at the disposal sites before and after transplanting work is completed. NMFS will prepare a report of their findings and conclusions for the COE at the end of the project. An environmental consulting firm will provide the labor and materials to do the seagrass planting work to COE specifications. Texas Department of Transportation is acting as the non-Federal sponsor.

Costs: Total estimated cost of the proposed project is $287,500 Oct. '94 P.L. ($295,841). There will be no future O&M costs or responsibilities associated with this project.

Outputs/Benefits: If the project is successful, the transplanting procedure can be used in other estuarine areas with a similar environment to reduce the recovery time of fish and wildlife resources in open-bay disposal areas.

LAKE WINNIBIGOSHISH, MINNESOTA
St. Paul District

Location: Lake Winnibigoshish is located in north central Minnesota about 100 miles west of Duluth, Minnesota, and 150 miles northwest of St. Paul, Minnesota. It is part of the Mississippi River Headwaters Project. The dam is located at the outlet of the lake on the Mississippi River about 15 miles north-west of Deer River, Minnesota.

Resource Problem: In the 1950s, the Minnesota Department of Natural Resources (MDNR) constructed four (4) fish rearing ponds immediately below the dam. These ponds were constructed in floodplain marsh habitat, resulting in the loss of approximately 85 acres of wetlands. The COE cooperated in this effort by allowing the MDNR to use the lake as a source of water supply and allowing the installation of the water intake pipe through the dam. These ponds have not been actively managed by the MDNR since the 1970's. Since that time, the ponds have taken on wetland characteristics in terms of vegetation and water levels. However, these wetlands do not function like natural floodplain wetlands because the dikes have cut off overland flow and prevent the river from flooding the wetlands during high water periods. The existing intake pipe and water distribution system could be used to create overland flow and flooding, but was precluded by sand clogging.

Management Measure: The water intake pipe for the ponds passes through the dam and extends approximately 110 feet into the lake. A gate valve is located on the upstream face of the dam, while on the downstream face a small structure houses a system of valves that regulates flow into the ponds. Each pond also has water inlet and outlet structures.

The project involves placing a 30-foot extension on the existing 24-inch water intake line. The purpose is to extend the intake pipe out to deeper water to reduce the problem of sand clogging the intake and downstream water lines.

Costs: The total project cost is estimated to be $74,600 Jan ‘93 ($79,822).

Outputs/Benefits: Installing the extension on the intake pipe would make water level management possible in ponds 2-4, restoring habitat quality to 44 acres of wetlands. The wetlands would be transformed from emergent wetland marsh with little standing water to wetlands with an average water depth of two (2) feet and with an emergent vegetation to open water ratio of 1:1. This is considered optimum for dabbling ducks. This effort would improve the habitat conditions for submergent vegetation with a concurrent increase in aquatic invertebrate production. The combination of these factors would increase the breeding and nesting waterfowl habitat. Wildlife that would benefit from improved habitat conditions in the project area include migrating waterfowl, aquatic and terrestrial furbearers, songbirds, amphibians, and reptiles.

LOWER TRUCKEE RIVER, NEVADA
Sacramento District

Location: The Truckee River flows from Lake Tahoe on the California side through Reno, Nevada, to Pyramid Lake. The principal study area includes the Truckee River and adjacent habitats below Vista, Nevada, to Pyramid Lake.

Resource Problems: The demand for water from this river has long exceeded the available water supply. Activities such as water diversions, flood control projects, and local developments have degraded the quality of fish and wildlife habitat on the lower reaches of this river. The problems have included lake subsidence, blockages to fish passage, bank erosion, loss of riparian habitat, degradation of instream habitat, geomorphic instability of the river channel, loss of historic old-growth riparian forests, and poor water quality. These problems have also led to listings of Lanhontan Cutthroat Trout (LCT) as threatened and the cui-ui as endangered. These problems have been created directly or indirectly by reduced flows in the river and have also resulted in major degradations of habitats. Flows have decreased because of current policies which give priority to upstream users and out-of-basin diversions.

Objectives: The following objectives were developed and used in the formulation of alternative plans for the reconnaissance study:

- Enable the efficient passage of cui-ui and LCT past instream impediments
- Improve spawning and migratory habitat for the cui-ui
- Improve spawning and migratory habitat for the LCT incidental to improvements made for the cui-ui
- Restore riparian habitat and vegetative cover
- Improve water quality in the lower Truckee River to enhance use by fish and macroinvertibrate species
- Minimize erosion to improve instream habitat conditions in the lower Truckee River
- Enhance recreation opportunities in the study area incidental to habitat restoration objectives
- Increase the level of flood protection in the Lockwood area
- Improve instream habitat for resident fish and wildlife

Management Measures: Twenty-six (26) managment measures were considered to support one or more of the study objectives. Due to the complexity of the river ecosystem, these 26 management measures were considered as basic components to model three (3) alternative river management plans. These three (3) plans address varying levels of effort and cover varying portions of the study area. Technically feasible and implementable measures were evaluated with regard to how well they satisfied prioritized goals. Management measures that aided the cui-ui were generally given a higher priority than those that favored the LCT. The priorities are: 1) Delta passage (cui-ui); 2) Habitat restoration below Numana Dam; 3) Habitat restoration Numana Dam to Wadsworth; 4)

Habitat improvements above Wadsworth; 5) Passage of Numana Dam (cui-ui); 6) Passage of Derby Dam (LCT); 7) Redesign of Marble Bluff Fishway; and 8) Improvement of adjacent upland habitats.

The three (3) alternative river management plans considered were:

- Alternative 1 - **Priority Objectives Plan** - which concentrates on the higher priorities addressing Delta passage and increasing the cui-ui population to carrying capacity below Numana Dam

- Alternative 2 - **Historic Range -** which builds on the first alternative plan with the expansion of habitat restoration to include more of the ecosystem

- Alternative 3 - **Comprehensive Plan** - which covers all reaches and uses larger structural approaches to solving problems in the study area

The management measures are further presented in Tables 6-9. Table 6 refers to each management measure and whether or not these measures were considered further. Tables 7-9 describes each of the management measures that were further considered in more detail along with the approximate first cost and O&M cost, if applicable. Tables 7-9 are grouped into the three (3) alternative river management plans previously identified.

The management measures for this study were primarily identified through coordination with the Fish and Wildlife Service, Pyramid Lake Indian Reservation, Natural Resources Conservation Service (formerly Soil Conservation Service), Nevada Division of Forestry, Bureau of Reclamation, and Nevada Department of Wildlife. These measures were arranged into four categories: 1) enable fish passage, 2) instream habitat improvements, 3) riparian vegetation restoration, and 4) river channel stabilization.

Outputs/Benefits:

- Reductions in dredging costs of $26,000 Oct. '91 P.L. ($29,120) - by stabilizing the river which would decrease sediment loading and resulting deposition of materials. A defined channel through the delta may concentrate spring spawning flows sufficiently to clear the lake berm that forms at the lake delta interface.

- Savings in hatchery operations costs of $50,000 Oct. '91 P.L. ($56,000) - by phasing out or reducing operations of a hatchery in the area if adequate natural spawning is established.

- Improved cattle grazing benefit of $56,400 Oct. '91 P.L. ($63,168) - by providing water sources in upland areas and improving use of existing upland range incidental to improving riparian vegetation.

- Flood Control - increased public safety and protection of public and private property.

- River Channel Stabilization benefits - increased protection of residential properties, protection of agricultural land, reduction of sediment transport, riparian habitat enhancement, and instream habitat enhancement.

- Federal Government benefits - reduced costs of managing and implementing recovery effects of endangered species, reduced operation and maintenance costs of fish facility, reduced Federal aid, and reduced flood control and relief costs.

- State of Nevada economic benefits - increased revenue from greater sales of hunting and fishing licenses, increased revenue from commerce and tourism relating to recreational activities along the river, education benefits to local schools and universities, and benefits resulting from the full implementation of P.L. 101-618.

- Pyramid Lake Paiute Tribe economic benefits - increased revenue from greater sales of fishing licenses, day use, camping, and boating permits; increased revenue from commerce and tourism relating to recreational activities along the river; restoration of an important sustenance fishery (cui-ui); and benefits resulting from the full implementation of P.L. 101-618.

- Local community economic benefits - increased revenue from commerce and tourism relating to recreational activities along the river, benefits resulting from the implementation of P.L. 101-618, and benefits resulting from increased drought storage.

TABLE 6
LOWER TRUCKEE RIVER, NEVADA
REVIEW OF MANAGEMENT MEASURES CONSIDERED

Management Measures	Further Consideration
Modify Lake Wave Angle - by using rock jetties or a breakwater	No- High risk of ineffectiveness; costly; visually disruptive
Channel Maintenance (Deepening) - by dredging annually to three (3) feet	No - High cost of dredging; potential negative impacts; lack of assurance
Transverse Fencing with Excavated Channel - by constructing fencing perpendicular to river	Yes
Transverse Fencing with Concrete Prismatic Channel - by constructing fencing perpendicular to river with prismatic concrete channel and training levee	No - High cost; Concerns from FWS; Uncertainty in estimating lake elevations
Improve Fish Handling Facilities - including: stabilize resting pool, extend a concrete wing wall, install electric weir, improve plumbing, add flow velocity reduction structures, and move exit of fishway	Yes
Remove Dam and Accumulated Sediment behind the Dam	No - Not a practical option, lots of mitigation
Remove Sediment from Dam - by excavating	No - Continual need to remove large sediment deposits
Artificially Transport Endangered Fish - by gathering, placing in trucks, and transporting to another location	No -High cost, human intervention, stress for fish, may involve other species
Reconstruct Fishway - to include redesigning and reconstructing fishway	Yes
Improve Fish Ladder and Screens - to include redesigning and constructing fish ladder	Yes
Construct Fish Ladder and 18 Screens	Yes
Improve Intergravel Environment - by promoting clean and properly graded gravel beds	Yes
Build Shade Structures	No - low likelihood for effectively improving water quality along the river
Restore Upland Vegetation - by controlling unwanted vegetation and replanting with native vegetation	Yes
Eradicate Tamarisk Trees - by cutting, burning the cuttings, applying herbicide to rooted stumps and replacing with riparian vegetation	Yes

TABLE 6
LOWER TRUCKEE RIVER, NEVADA
REVIEW OF MANAGEMENT MEASURES CONSIDERED

Management Measures	Further Consideration
Plant Riparian Vegetation - by planting cottonwoods and willows along the river and into the floodplain	Yes
Enhance Palustrine Habitat - by creating oxbow ponds, sloughs, and other wetland habitats using weirs and planting with emergent vegetation	Yes
Check Dams to Control Water Levels - by constructing small dams using local riverbed materials	Yes
Control Beaver Population - by eradicating or limiting	Yes
Cattle Grazing Capital Improvements - by constructing fencing around riparian areas, wells, and watering troughs in upland areas	Yes
Establish and Maintain a Meander Zone - through acquisition of lands or easements so river could meander freely within the zone	No - due to long time frame as compared to active stabilization measures
Structural Protection of Banks and Valley Walls - possible methods - bank revetment, dikes, live crib walls, windrows, and brush matting	Yes
At-Grade Control Structures - by constructing a hard point on channel bottom to reinforce existing natural grade control	Yes
Deflector Structure - by constructing a wall, fence, or dike to deflect the main channel in a smoother path around bends to keep the river from braiding and potentially flanking of hard points	Yes
Raise the River Channel - to emulate historic conditions by using drop structures or transverse fences to trap and deposit sediments	No - Technically infeasible; Expensive
Flood Control Features - by constructing a flood detention dam or levees along the river	No - No cost effective solution identified

TABLE 7
LOWER TRUCKEE RIVER, NEVADA, MANAGEMENT MEASURES
ALTERNATIVE 1 - PRIORITY OBJECTIVE PLAN

MANAGEMENT MEASURE	DESCRIPTION	FIRST COST (Oct '91 P.L.)	O&M COSTS
Transverse Fencing with Excavated Channel	Fences spaced 1,000 feet apart; fences consist of wood posts (metal every 10th post) with 36-inch wide AV (cloth) netting (½-inch opening) strung between posts, 6 foot on center. Fences extend from channel to valley wall. The excavated pilot channel would be approximately 3 feet deep and 50 feet wide. O&M costs based on 25% replacement of netting each year.	$330,000 ($369,600)	$6,125 ($6,860)
Plant Riparian Vegetation	Area replanted is 552 acres. Plantings would be within 165 feet of the river. Plant material is nursery grown pole cuttings, 500 plants per acre. Holes are augured for placement of cuttings. No irrigation is included. Unit cost is $7,000 ($7,840) per acre. Planting would be accomplished over a period of 15 years. First costs represents the present worth of the annual cost. O&M cost is $10 ($11) per acre.	$2,140,000 ($2,396,800)	$5,520 ($6,182)
Check Dams to Control Water Levels	Dams would be made of local rock and stone. Embankments upstream and downstream slopes would be 3V to 1H; the crown width would be 5 feet. Each dam would be 200 feet long. The spillway would be 50 feet wide and line with a plastic membrane. Four dams would be built and breached each year over a period of 5 years. First cost represents the present worth of the annual cost.	$160,000 ($179,200)	
Control Beaver Population	Control is introducing sterile beaver and trapping and shooting beaver. Unit cost is $838 ($939)/mile/year. Control would be 30.5 miles. First cost is present worth of the annual cost. Annual cost is $25,600 ($28,672).	$300,000 ($336,000)	
Cattle Grazing Capital Improvements	Fencing would be 5 strand barbed wire, erected along both sides of the river for a length of 45 miles (fencing skirts oxbows). 16 wells installed with troughs, tanks & solar pumps. Depth of wells - 50 feet.	$1,340,000 ($1,500800)	$3,250 ($3,640)
Structural Protection of Banks and Valley Walls	Riprap, approx. 24 feet thick with a built up toe section; avg. hgt. is 10 feet. Unit cost is approx. $100 ($112) per linear foot. First costs are broken down by reach. Total 28,400 linear feet. Costs of other bank stabilization options not included with this plan: a) If fence deflectors were employed, the cost would be $10 ($11) per linear foot with a higher O&M cost; b) If repair of existing revetment is required, the cost would be $110 ($123) per linear foot. O&M is $150 ($168) per mile per foot of height.	$3,050,000 ($3416,000)	$8,100 ($9,072)
At-Grade Control Structures	Two grade control structures would be built using sheet metal pile walls driven into the streambed. The sheet piling would extend approximately 20 feet below the streambed grade and extend the width of the river plus 10 feet on both sides (230 feet).	$520,000 ($582,400)	
Deflector Structures	Berms made of local rock. First costs are broken down by reach. Structure along bank of 800 linear feet - $40,000 ($44,800). Including pilot channel excavation of 600 linear feet - $540,000 ($604,800).	$580,000 ($649,600)	

TABLE 8
LOWER TRUCKEE RIVER, NEVADA, MANAGEMENT MEASURES
ALTERNATIVE 2 - HISTORIC RANGE PLAN

MANAGEMENT MEASURE	DESCRIPTION	FIRST COST	O&M COSTS
Transverse Fencing with Excavated Channel	Same as Alternative 1	Same as Alt. 1	Same as Alt. 1
Plant Riparian Vegetation	Area planted is 20 acres more than Alternative 1 totaling 572 acres.	$2,220,000 ($2,486,400)	$5,720 ($6,406)
Check Dams to Control Water Levels	Same as Alternative 1	Same as Alt. 1	Same as Alt. 1
Control Beaver Population	Same as Alternative 1	Same as Alt. 1	Same as Alt. 1
Cattle Grazing Capital Investments	Same as Alternative 1	Same as Alt. 1	Same as Alt. 1
Structural Protection of Banks, Valley Walls	Same as Alternative 1	Same as Alt. 1	Same as Alt. 1
At-Grade Control Structures	Same as Alternative 1	Same as Alt. 1	Same as Alt. 1
Deflector Structures	Same as Alternative 1	Same as Alt. 1	Same as Alt. 1
Improve Fish Ladder and Upstream Screens	Flattening existing fish ladder slope, increasing # of resting pools (17 to 26), installing 1 screen at site & 5 upstream screens. Increase in O&M cost is an average of $500 ($560) per screen.	$1,120,000 ($1,254,400)	$3,500 ($3,920)
Restore Upland Vegetation	Clearing and burning weedy species, applying herbicide, and reseeding or replanting with desirable upland plants. Unit cost is $15,000 ($16,800) per acre. Thirty four acres would be restored in all but one subreach. O&M of upland vegetation is $7 ($8) per acre.	$2,010,000 ($2,251,200)	$938 ($1,051)
Remove Tamarisk	The unit cost for tamarisk eradication is $15,000 ($16,800) per acre; it includes clearing and burning tamarisk, application of herbicide, and planting riparian vegetation. O&M of riparian vegetation is $10 ($11) per acre.	$200,000 ($224,000)	$130 ($146)
Enhance Palustrine Habitat	Constructing an upstream rock weir and a downstream dam on 3 oxbow sites, grading, and planting using local cutting and division plant material. Each site assumed to increase wetlands area by 9 acres. O&M is $2,500 ($2,800) for each site.	$280,000 ($313,600)	$7,500 ($8,400)

TABLE 9
LOWER TRUCKEE RIVER, NEVADA MANAGEMENT MEASURES
ALTERNATIVE 3 - COMPREHENSIVE PLAN

MANAGEMENT MEASURE	DESCRIPTION	FIRST COST	O&M COSTS
Trans. Fencing w/ Excavated Channel	Same as Alternative 1	See Alt. 1	See Alt. 1
Plant Riparian Vegetation	Includes all potential planting sites in all subreaches. Totaling 1,295 acres.	$5,020,000 ($5,622,400)	$12,950 ($14,504)
Check Dams to Control Water Levels	Same as Alternative 1	See Alt. 1	See Alt. 1
Control Beaver Population	Same method as Alternative 1 but cover more area.	$570,000 ($638,400)	
Cattle Grazing Capital Improvements	Same as Alternative 1	See Alt. 1	See Alt. 1
Struct. Prot. of Banks & Valley Walls	Same as Alternative 1	See Alt. 1	See Alt. 1
At-Grade Control Structures	Same as Alternative 1	See Alt. 1	See Alt. 1
Deflector Structures	Same as Alternative 1	See Alt. 1	See Alt. 1
Improve Fish Ladder & Upst. Screens	Same as Alternative 2	See Alt. 2	See Alt. 2
Restore Upland Vegetation	Same as Alternative 2	See Alt. 2	See Alt. 2
Remove Tamarisk	Same as Alternative 2	See Alt. 2	See Alt. 2
Enhance Palustrine Habitat	Restoration at 7 oxbow sites, otherwise same as Alternative 2	$460,000 ($515,200)	$17,500 ($19,600)
Improve Fish Handling Facilities	Stabil. dam fishway rest. pool, extend cncrt wing of rest. pool, excavate river trap channel to 6 ft, excav. resting pools in river trap channel at 6-10 foot intervals, install elect. weir, & upgrade plumb.	$550,000 ($616,000)	
Reconstruct Fishway	New fish ladders, enlarged channel, resting pools, new upstream exit above dam, adjustable weirs, & upgrading of fish trap, access road, maintenance building, & office. O&M remove silt & debris.	$20,300,000 ($22,736,000)	$20,000 ($22,400)
Fish Ladder and Screens at Dam Site	Construct fish ladder, 1 onsite screen and 18 upstream screens. Annual O&M costs would include $7,400 ($8,288) for ladder, and cleaning the dam and upstream screens.	$5,280,000 ($5,913,600)	$20,150 ($22,568)
Improve Intergravel Environment	Purch., haul., & place. gravel to thickness of 6 in. strmbd locations. Total area treated 44,000 sq. ft.	$20,000 ($22,400)	

MCFADDIN RANCH WETLANDS, TEXAS
Galveston District

Location: The proposed project is located on the McFaddin National Wildlife Refuge, Sea Rim State Park, and the Murphree Wildlife Management Area in Jefferson County, Texas. The area is located just southwest of Port Arthur, Texas, and just south of the Gulf Intracoastal Waterway (GIWW) and just west of the Sabine-Neches Waterway.

Resource Problems: Historically, the project area consisted of fresh to brackish marshlands drained by a long series of bayous and lakes to Sabine Lake. The construction of Federal navigation projects have resulted in degradation of about 60,000 acres of publicly owned wetlands by introducing salt water into the area directly from the Gulf of Mexico. Increased salinity has contributed to loss of submerged vegetation, conversion of vegetated areas to open water, and reduced wildlife habitat values.

Objective: The objective of this project is to reduce saltwater intrusion from the GIWW into a historically fresh to slightly brackish marsh.

Management Measures: The following describes the proposed management measure which is to construct a gated concrete water control structure and its components for this project.

Construct a Gated Concrete Water Control Structure - It would contain 5 gated culverts. Each of the gated culverts will be equipped with a sluice gate on the marsh side and a flap gate on the GIWW side. The sluice gates will be operated using a portable drive unit.

- Excavate an Intake Outlet Channel - Between the existing bayou and the new structure.
- Excavate an Outlet Channel - Between the new structure and the GIWW.
- Dam Existing Salt Bayou Outlet Channel - With material from the excavation for the new structure and channel and from new cut dredged material placed along the south bank of the GIWW when the waterway was originally dredged. This will block the existing bayou at the GIWW and force water flow through the new structure and channel between the marsh and GIWW.
- Install Boat Roller System - Adjacent to the new structure.
- Install Stone Riprap- Installed at the water control structure and along the new channel.
- Construct Training Levees - On both sides of the new structure and along the GIWW.

Cost: The total estimated first cost of the proposed project is $1,945,000 Feb '92 P.L. ($2,139,500). The Texas Parks and Wildlife Department is the local sponsor for this project and was very involved throughout all stages.

Other Management Measures Considered:

- No Action Alternative - eliminated because it would not contribute to important State and National goals of preserving wetlands for fish and wildlife resources by halting further deterioration of the area.

- Block Salt Bayou - Dam only - a riprapped earthen dam to alleviate the damaging influence on the marsh of saltwater intrusion at Salt Bayou. Although, this alternative would reduce the rate of future marsh loss, it would not preserve the area in even its present deteriorated state, nor would it provide for any active management of fish and wildlife habitat. This type of dam would not make it possible to influence water levels and salinity to restore the marsh to near its historical habitat value by encouraging the growth of a diverse wetland plant community of high value to wildlife. Also, a dam at Salt Bayou would greatly reduce the effectiveness of the existing structure (first gated structure) at Star Lake, by not allowing the two (2) structures to operate as a system.

Outputs/Benefits: Habitat improvement for waterfowl was chosen as the best indicator of an overall wildlife habitat improvement. The mottled duck was chosen as the species for which habitat improvement would be judged because of it being a year round resident of the area. This would be an ideal species to represent both waterfowl and other resident wildlife in the project area. A dam and water control structure would increase the Habitat Suitability Index (HSI) of the project area to 0.79, a 155 percent improvement above the without project condition.

ORWELL DAM/LAKE, MINNESOTA
St. Paul District

Location: Orwell Dam/Lake is in Otter Tail County in west-central Minnesota, approximately 150 miles northwest of Minneapolis and about six (6) miles southwest of Fergus Falls, Minnesota. The dam is on the Ottertail River, 33 miles upstream from where the Ottertail and Bois de Sioux Rivers join to form the Red River of the North.

Resource Problem: At higher pool elevations caused by rainfall events and snowmelt, the reservoir inundates several connected wetland areas and shallow marsh habitat. Some of the wetland/marsh areas retain water in their basins as the reservoir drops to normal pool elevation, while others become dry. These water level fluctuations have decreased aquatic vegetation in littoral areas of the reservoir which limits the fishery and wildlife potential in the area. These existing conditions have prevented the full development of perennial emergent vegetation in the wetlands connected to the reservoir, as well as submergent aquatic species. The lack of submergent and emergent vegetation substantially reduces the value of these areas to nesting waterfowl because of the lack of cover and scarcity of aquatic macroinvertebrates necessary for breeding and brood rearing. Also falling water levels strand waterfowl nests and their broods, subjecting them to higher predation.

In the upland areas adjacent to the reservoir, there are approximately 725 acres of open grassland. Sparse vegetation consisting primarily of smooth brome is found on 700 acres, with native grasses covering the remaining area. Monotypic stands of grasslands increase nest predator hunting efficiency, decreasing the overall waterfowl nesting successes of the area. Monotypic vegetation also reduces the availability of alternate sources of prey, such as, mice, moles, and rabbits which again decreases the overall nesting success.

Objectives: The goals of this project are to restore wetlands on Orwell Lake project lands, to increase the habitat value of the existing wetlands in the project area, to restore upland nesting habitat for wildlife, and to increase the overall value of Orwell Lake and the surrounding area for fish and wildlife. The following two objectives were established to achieve these goals: 1) to create a number of smaller impoundments such that manageable wetland areas would be restored, and 2) to restore the diversity of upland habitat.

Management Measures: The management measures and their components consist of constructing three (3) controlled subimpoundments within the reservoir and plantings in upland areas. The subimpoundments would be filled by runoff from their watersheds. The construction of the control structures would allow periodic summer drawdowns to restore the aquatic habitat on each subimpoundment, and would also increase the wetland size by holding backwater in the subimpoundments. For identification reasons, each subimpoundment was assigned a number.

Subimpoundment 2: Given the size of the watershed for this area (340 acres), the overflow control structures associated with the dike at this location would consist of a sheetpile weir with stoplog bays. The width of the overflow weir would be 25 feet with two (2) five-foot stoplog bays. The dike would have a top width of 12 feet, with side slopes of 1V on 3H. Riprap and fabric would be placed upstream and downstream of the sheetpile structure to protect its integrity and for energy dissipation. The riprap would be 24 inches thick on the downstream side, extending 20 feet from the structure. The riprap would be 18 inches thick on the upstream side, extending 10 feet. A 20-foot-wide grass-lined emergency spillway would be part of the dike structure. By constructing this structure, this subimpoundment could be drawn down every five (5) to seven (7) years, and the water levels could be stabilized almost every year to promote vegetative growth and shoreline stabilization.

Subimpoundment 7: This area is a perched wetland. To provide opportunities for regulated inflow and outflow from this area, a control structure/dike system with a 450-foot channel would be constructed at the downstream opening to the main reservoir. This would allow wildlife managers to periodically draw the water in the wetland down to stimulate the growth of aquatic vegetation. At the outlet from the wetland, an earth dike with standpipe control structure would be constructed. The control structure would consist of a 6-foot-diameter half-round upright corrugated metal pipe with slots for stoplogs, connected to a 3-foot-diameter outlet pipe that runs through the dike. The top width of this dike would be 12 feet, with side slopes of 1V on 3H. To minimize water fluctuations due to storm events, the dike would have a 20-foot-long grass-lined spillway which has been sized to accommodate outflows during flooding. The spillway crest would be one (1) foot below the top elevation of the berm.

A channel would be excavated from the control structure to the main flow area within the reservoir. Approximately 600 cubic yards of soil and sediments would be removed and spread over a one (1)-acre agricultural field. The total length of the channel would be 450 feet. The bottom width would be 20 feet and the side slopes would be at the angle of repose.

Subimpoundment 9: The south arm of the reservoir is currently separated from the main reservoir as a subimpoundment. A standpipe/culvert control structure was placed through an existing road in 1986 to create this impoundment. Although the water elevations here are currently managed independently from Orwell Reservoir, effectiveness is very limited because fluctuations in water levels continue to reduce the growth of aquatic vegetation and inundate waterfowl nests. The "bounce" in water levels is well beyond the design criteria for subimpoundments, with variations as great as six (6) feet noted after some storm events. Due to the differences in existing bottom elevations, the desirability of splitting this impoundment into two smaller areas was evaluated. This was necessary, because, at the design subimpoundment pool elevation of 1,068 feet msl, water depths of eight (8) feet or greater occur in the north end. This allows carp to overwinter here, lowering the value of the entire wetland area because of the negative effects they cause. It was determined that subimpoundment 9 should be created south of these deeper areas.

Subimpoundment 9 would be operated at 1,068 msl. To properly control the "bounce" in subimpoundment 9, a sheetpile weir would be needed. This weir structure would be constructed in the narrow portion of the reservoir. Given the surrounding topography, this structure would be wrapped into a three-sided rectangular or semi-circular shape, eliminating extensive excavation that would have been required to fit in a more typical linear weir structure. The weir length at this location would be 90 feet, with the top of the weir set at elevation 1,068 feet msl. Two (2) stoplog bays would be needed in the structure.

To provide full manipulation of subimpoundment 9, an existing dike near the middle of the impoundment would be breached. A 2,000-foot channel with a bottom elevation of 1,061 msl would be excavated to facilitate winterflow. The remaining dimensions would be the same as for the subimpoundment 7 channel. Approximately 5,800 cubic yards of soil and sediments would be removed by this excavation and side cast on adjacent grassland. If future cultural resource investigations preclude the use of these areas, the material would be spread over a 7-acre field. The area in subimpoundment 9 would be enhanced since the possibility of occasional drawdowns would be available, plus the water level fluctuations would be controlled which would promote growth of aquatic vegetation, stabilize shorelines, and limit waterfowl nest flooding.

Prairie restoration at six (6) areas totaling 115 acres throughout the Orwell Wildlife Management Area (OWMA) would be carried out by the Minnesota Department of Natural Resources (MDNR). All areas would be treated with environmentally acceptable herbicides, burned, and planted with native grasses and forbs. The seed mixture would be suited for individual site conditions for optimal plant response. All planting would be done in spring to early summer using a Truax seed drill. Because a MDNR Truax drill is available for use at OWMA, the extent of Federal involvement under Section 1135 would be limited to supplying the seed mix and herbicide required for the proposed plantings. (The MDNR estimates that it would cost them approximately $4,000 ($4,360) to seed the areas where prairie restoration has been proposed).

Costs: The total project cost for the selected plan was estimated to be $224,000 Oct. ‘92 P.L. ($244,160).

Benefits: Approximately 190 acres would be directly affected by creation of the subimpoundments and prairie restoration phases.

SAMMAMISH RIVER, WASHINGTON
Seattle District

Location: The study area is located approximately five (5) miles east of Seattle, King County, Washington. The authorized project consists of channel improvement for flood control. Flood protection was provided by enlarging (deepening) and channelizing (straightening) the river from Lake Sammamish to Lake Washington for approximately 14 miles.

Resource Problems: A channel improvement project that was completed in 1966 has had several negative fish and wildlife impacts. These impacts include:

- Restricted use by salmonids as a migratory route between Lake Washington and Lake Sammamish
- Removal of adjacent vegetation eliminated shading, feeding, and resting habitat for fish and permitted greater exposure of fish to predation
- Passage to several tributaries is severely restricted or prohibited by the deepening of the channel and lowering of the surface water level, resulting in the loss of available spawning habitat
- Higher water temperatures and decreased oxygen levels, especially in the summer months
- Fishery resources greatly reduced
- Wildlife habitat associated with the riparian and adjacent wetland vegetation greatly reduced

The channel improvement project lowered the channel bed an average of five (5) feet and increased widths from an average of about 15 feet to a range of 32 to 50 feet. Channel banks were excavated to a 1V on 2.5H slope in which rock was placed along the toe to prevent erosion. The remaining slope was seeded with grass with no woody/leafy vegetative plantings. Existing river meanders were eliminated. Average design-condition velocities are on the order of two (2) to three (3) feet per second with depths of about 10.5 feet.

Objectives: The following planning objectives were developed and used in the formulation of alternative plans for this project:

- Restore the stream channel to provide suitable migratory, reproductive and rearing habitat for salmonid species
- Restore riparian lowland vegetated bench along the west side of the Sammamish River

- Restore patterns of current direction and velocity within the relatively straight channel that will scour pools in the river bed, lend greater hydraulic diversity to the river, and concentrate current to the bank areas (where hiding fish can feed)

- Restore submerged and closely overhanging cover for fish in the areas on both the east and west banks

- Restore channel side slopes of varied form above the new riparian bench in order to promote habitat diversity for wildlife

- Restore diversity of native trees and shrubs along the middle and upper banks to provide food and cover for wildlife and to shade the river

Management Measures: A study team was formed to evaluate the environmental needs of the project area and to determine the most beneficial utilization of funds. The team was comprised of district and division personnel, along with individuals from the Washington Department of Fisheries and Wildlife, Muckleshoot Indian Tribe, and the local sponsor. Eight (8) sites were initially selected for consideration. Each site was ranked for the following criteria:

- Fish habitat improvements (e.g., pool/riffles, shade, resting areas, increased spawning area)

- Wildlife habitat improvements (e.g., increased protective cover, foragable food source, connection to corridor or migration route)

- Recreation benefit

- Opportunity for volunteer participation

- Educational opportunities

The last three criteria were not applied in making final site selections. The selected plan comprises three (3) sites representing the highest ranking of all sites considered by the study team and are within the funding limitations of the sponsor. The proposed management measures consist of a combination of structural (bank excavation, installation of log structures, low flow deflectors, and a foot bridge) and nonstructural (revegetation) elements. The total channel length of the project area is approximately 2,400 feet including three (3) distinct sites. **Site 1** is a tributary which flows into the Sammamish River. Currently, the tributary empties into the river through two (2) 36-inch culverts positioned four (4) feet above the river at ordinary high water. These culverts obstruct fish passage between the mainstream and tributary. **Site 2** is located just north of a tributary which empties into the Sammamish River. **Site 3** is located north of another tributary which empties into the Sammamish River. Each of the three (3) sites are described below.

Site 1

- Create a Meandering Channel - excavating a new tributary channel section approximately 250 feet long which will bypass the culverts. The culverts will remain in place but will be plugged for safety.
- Install Two (2) Log Sills.
- Plant Native Vegetation - adjacent to the new channel and along the Sammamish River.
- Construct Footbridge - create a 40-foot-wide by 10-foot-high tributary corridor. The cut beneath the proposed footbridge will be stabilized with 20 tons of quarry spalls (fragments) for added protection. 550 cubic yards of material will be excavated.
- Plant Native Trees and Shrubs and Hydroseed - at excavated slopes, trees will be selected to ensure that individual trunk sizes do not exceed 18-inch-diameter (at maturity). Shrubs would be densely planted in blocks 75 to 150 feet long, from summer low water to the top of bank.

Site 2

- Three (3) Log Sills.
- Three (3) Log Habitat Features - consisting of logs and tree trunks anchored into the bank at low water elevation with 30 tree root wads extending two (2) feet into the channel.
- Excavation and Benching - approximately 5,100 cubic yards of material will be excavated and disposed of at an upland site.
- Quarry Spalls - 80 tons.
- Plant Native Shrubs and Trees - trees will be selected to ensure that individual trunk sizes do not exceed an 18-inch diameter (at maturity). Shrubs would be densely planted in blocks 75 to 150 feet long, from summer low water to the top of bank.

Site 3

- Install Four (4) Low flow Deflectors.
- Install Four (4) Log Habitat Features - same as used at Site 2.
- Excavation and Benching - at a distance of 1,150 feet, approximately 5,400 cubic yards of material will be excavated and disposed of at an upland site.
- Quarry Spalls - 300 tons.
- Plant Native Trees and Shrubs - same as Site 2.

Costs: Construction is completed. The total cost for the three (3) sites, including engineering and design, LERRD, Modification Evaluation, and Detailed Report Cost is $440,000 Oct. '93 P.L. ($466,400). The local sponsor intends to use this project as a prototype for future modifications, which would include extensive bank modifications and revegetation, installation of channel drop structures, low flow deflectors, and re-creation of meander channels.

Outputs/Benefits: This plan will restore some of the riparian habitat and pool-riffles and restore access to a tributary stream which historically had salmon and steelhead spawning. This will serve to benefit both anadromous fish and wildlife. This will also improve spawning habitat resulting in an annual increase in production of approximately 352 adults. For migrating benefits, the proposed improvements would enhance the survival of anadromous fish migrating by two (2) to three (3) percent annually, or approximately 720 fish. This translates into increasing numbers of natural and hatchery spawning fish available for the commercial, sports, and tribal fisheries. Water quality benefits will occur. Wildlife benefits will occur for many species, particularly furbearers and carnivores, as well as waterfowl, passerine and raptors. The aesthetic appearance of the river will also improve.

SONOMA BAYLANDS TIDAL WETLANDS RESTORATION, CALIFORNIA
San Francisco District

Location: The project modification site is located in Sonoma County, California, approximately eleven (11) miles southeast of the city of Petaluma, California, near the mouth of the Petaluma River, between the northern shoreline of San Francisco Bay and State Highway 37.

Resource Problems: Approximately 75 percent of the original tidal wetlands of San Francisco Bay have been destroyed by diking and filling. This loss of wetlands has greatly reduced the habitats of many species of fish and wildlife. Several local animal and plant species have been listed as endangered due to the reduction of their wetland habitats. The disposal of dredged material from San Francisco Bay is currently constrained by the lack of suitable disposal sites. Restoration of tidal wetlands on subsided, diked lands using dredged material will help offset historic habitat losses and provide a beneficial use for dredged material. A restoration project on the Sonoma Baylands site will improve construction techniques and increase agency and public support for beneficial uses of dredged material.

Objectives: To restore a diked, subsided former tidal wetlands using maintenance dredged material from the portion of the Petaluma River channel in San Pablo Bay.

Management Measures: Construction of a levee around the landward limits of the restoration site will prevent tidal flooding of the adjacent lands. Two (2) peninsulas, which will act as wind-wave barriers, will be constructed within the site. Dredged material from the presently scheduled maintenance dredging of the Petaluma River channel will be hydraulically pumped into the restoration site to increase the ground elevation of the subsided land.

The 830-acre Sonoma Baylands site is a diked former tidal wetland that is currently used as an oat hay farm. The site has been acquired by the Sonoma Land Trust using funds provided by the California State Coastal Conservancy (CSCC). Additional CSCC funds were subsequently used to complete a tidal wetlands restoration design for a 322-acre area at the southern end of the site. The technical consultants who prepared the restoration design determined that the use of dredged material would be the best means of restoring tidal salt marsh habitat on the site. The 322-acre area proposed for wetlands restoration is transversed by a high voltage power line on four (4) metal lattice towers. Because of the requirement for maintenance access to the towers, the CSCC's restoration plan includes a continuous, sinuous levee along the alignment of the power line. This access levee divides the restoration area into a small western section and a much larger eastern section. The size of the Section 1135 restoration site was determined by matching the estimated quantity of material to be dredged, 3,000 cubic yards, to the design elevation for the restored tidal marsh at +2 ft. NGVD.

Costs: The total cost of this project is approximately $792,000 Feb. ‘92 P.L. ($871,200).

Outputs/Benefits: The project modification will restore 31 acres of intertidal mudflat and wetland habitat and peripheral terrestrial habitat. The restored habitat will support a wide variety of fish and wildlife resources, including juvenile estuarine fish, migratory waterbirds, and endangered species. The project modification is specifically designed to restore habitat for two Federally-listed endangered species.

YOLO BASIN WETLANDS, SACRAMENTO RIVER, CALIFORNIA
Sacramento District

Location: The Yolo Bypass is an operative feature of the Sacramento River Flood Control Project. The project is located on the Sacramento River and the lower reaches of its main tributaries are in north-central California. The principal features of the flood control project extend from Ord Bend downstream to Collinsville totaling a distance of 184 miles. Features include a comprehensive system of levees, overflow weirs, drainage pumping plants, and flood bypass channels. Approximately 1,000 miles of levees provide flood protection to about 800,000 acres of highly productive agricultural lands in the Sacramento Valley and Sacramento-San Joaquin Delta and to the urban areas of Sacramento and Marysville/Yuba City and many other smaller communities. The Bypass is located immediately west of the metropolitan area of Sacramento. The Bypass lies in a general north to south orientation and extends from Fremont Weir downstream to Liberty Island, a distance of about 43 miles. The Bypass is bound by high levees (up to 20 feet) with a general crown width of 20 feet, landside slopes of 1V on 2H and waterside slopes of 1V on 3H. Levee embankments are generally between 10 to 20 feet high, based on heights above the land surface on the landward side of the levee. The Bypass encompasses about 40,000 acres and varies in width from about 7,000 feet near the Fremont Weir to about 16,000 feet at Interstate 80. The design flow capacity varies from 343,000 cubic feet per second at the Fremont Weir to 500,000 cubic feet per second at the downstream limit, with a design freeboard of six (6) feet.

Resource Problems: Due to the construction of the flood control project and draining and leveling of the land for agricultural use, only remnants of permanent and seasonal wetlands remain today. An estimated 97 percent of the State's historic wetlands and riparian forests have been cut, cleared, and converted to other uses. Habitat losses within the Bypass have been similar, if not greater. As a result, the wildlife species that depended on the historic wetlands and forests have declined dramatically, and many native plant and animal species have vanished.

Objectives: The objectives of this project are the restoration of historic wetlands in the Yolo Basin Wetlands area and support of the goals and objectives of the North American Waterfowl Management Plan (NAWMP) and the California Central Valley Habitat Joint Venture (CVHJV).

Management Measures: Wildlife habitat development is proposed for three (3) areas, Putah Creek Sinks, Yolo Causeway, and Davis site, within or immediately adjacent to the existing Sacramento River Flood Control Project (SRFCP). A general description and location of each area are discussed in the following paragraphs.

Putah Creek Sinks. This area is located within the Yolo Bypass, approximately 5,000 feet south of the Interstate 80 bridge crossing. The City of Sacramento lies about four (4) miles to the northeast. This wildlife area encompasses approximately 3,000 acres. Approximately 2,323 acres are proposed for seasonal wetland development, 464 acres for grassland/upland development, 28

acres for riparian woodland and 185 acres for permanent wetlands. The seasonal wetlands shall be provided by sectioning the above acreage with a low berm, approximately two (2) feet high. The berm shall have a crown width of 12 feet with 1V on 2H sideslopes if adjoining permanent wetlands, and 1V on 5H sideslope if adjoining seasonal wetlands, grassland, or riparian woodland. The total length of the berm is approximately 167,300 feet. Approximately 700,000 cubic yards of excavation will be required (permanent wetlands and stripping for berm). Approximately five (5) percent of the permanent wetland area will remain unexcavated to provide waterfowl resting areas just under the normal water surface. Approximately 100,000 cubic yards will be used as grading material for the riparian woodland establishment. The construction of the berm will require approximately 425,000 cubic yards (all from excavation). Approximately 80,000 cubic yards of material will be spoiled immediately for grading/leveling fill within the grassland/upland areas.

Approximately 16.5 miles of all-weather road will be provided. The all-weather road shall consist of a crushed rock road base surface course, four (4) inches thick and 15 feet in width. The all-weather road shall be located essentially near the outermost boundaries of the developed habitat tracts, crossing the project laterally only at the northern, middle and southern points of the project, and located on the berm only when necessary and, accordingly, shall be only 12 feet in width in those instances.

The permanent wetlands shall be provided by the excavation of approximately two (2) feet of the existing grade and construction of the berm. The permanent and seasonal wetlands shall be flooded and drained by a series of 67 small flood turnouts (12- and 36-inch interior diameter conduits with slide gates) with concrete headwalls. The permanent wetlands shall be connected by short canals and may be operated in series or independently (total length of canals approximately 24,000 linear feet and 19 feet wide by two (2) feet deep in cross section). Supply inlets and short supply canals will be constructed and operate by gravity to flood the adjacent and connecting ponds. Two additional pumps, 75 horsepower each, will be installed to assure sufficient capacity for flood-up of the wildlife areas. Public parking will be provided at two (2) locations (10-15 cars each).

Costs: The total approximate cost for Putah Creek Sinks is $3,210,000 Oct ‘91 P.L. ($3,595,200).

Yolo Causeway. The Yolo Causeway proposed development encompasses 480 acres of which approximately 392 acres are of grassland/upland habitat, 83 acres are of riparian woodland, and five (5) acres are of permanent wetland. The entire 480 acres will be sacrificed to prepare the area for planting. The wetland berm shall be designed as in Putah Creek Sinks and only included for the permanent wetland pond (excavate two (2) feet with approximately a two-foot high berm). The structural features will include an all-weather maintenance road (same as Putah, approximately 6.5 miles in length) and the same public parking area. The main source of water for the initial flood-up of the permanent wetland pond will be the toe drain. A supply inlet and drain and pump will be

provided for the permanent wetland area and irrigation of the riparian woodland area from this source.

Costs: The total approximate cost for Yolo Causeway is $840,000 ($940,000).

Davis. The Davis site will be a separate Section 1135 study from the Yolo Basin Wetlands study. The general project layout is comprised of stormwater pond (utilized as a seasonal wetland area), wastewater pond (also utilized as a seasonal wetland area), mixing/distribution area, shallow meadow marsh areas (seasonal wetland) and permanent wetland areas, public parking area, and pedestrian trail (natural earthen trail). The proposed development encompasses approximately 345 acres, including 144 acres of seasonal wetland, 65 acres of riparian woodland, and 136 acres of permanent wetland. The stormwater tract, approximately 250 acre-feet capacity, will store urban and agricultural runoff transported to the site by a earthen diversion channel, 8,000 feet in length, average depth four (4) feet, bottom width 20 feet, side slopes of 2V on 1H and approximately 200 cfs capacity, diverted from Willow Slough Bypass. Overflow from the stormwater tract will be directed to the central permanent wetland areas and peripheral pond. During normal operations (other than high runoff periods), a pump station (approximately three (3)-12.5 horsepower, two operating, one standby) will lift the stormwater to the central wetland area.

The wastewater seasonal wetland area, approximately 40 acre-feet capacity, will receive effluent from the adjacent City of Davis wastewater reclamation plant, approximately 5 to 7.5 MGD for two-thirds of the year. The wastewater pond will be able to operate with or independently of the central permanent wetland. The mixing/distribution facility will blend stormwater, when available, with wastewater. It will be situated at the highest elevation to permit gravity flow through the system. Following a storm event, the wastewaters could be blended with storm waters and then distributed to either the meadow marshes or central permanent wetland. The water will drain through the system by gravity (in a horseshoe pattern) from the high inlet point at the northeast corner of the area. At this point, the water will be discharged into the Willow Slough Bypass or recirculated by a 12.5-HP pump and small canal through the system again. The decision to recirculate or drain the system will depend on the available inflow to the project.

Berms for the seasonal and permanent wetlands would vary in height from two (2) to four (4) feet. The sideslopes would be 1V on 2H for the permanent wetlands and 1V on 5H for the seasonal wetlands. The total length of berms is approximately 35,000 feet. Excavation for the wastewater pond would be approximately four (4) feet and approximately three (3) feet for the central permanent wetland area. Islands (approximately 20 acres) for riparian woodland establishment would be created by the use of excess excavation, approximately four (4) feet of fill.

A maintenance road will be provided at the perimeter of the site (approximately 3.5 miles) as well as a parking area for about 10-15 cars.

Costs: The total approximate costs for the Davis site is $1,670,000 Oct 1991 P.L. ($1,870,400).

Outputs/Benefits: The proposed restoration work would markedly increase habitat value at all sites. The Putah Creek Sinks Site would show an increase of about 1,447 AAHU; the Yolo Causeway Site would increase by about 168 AAHU; and the Davis Site would increase by about 118 AAHU.

The FWS estimated the peak potential winter waterfowl use days and average annual number of fledglings for each site. Peak potential wintering waterfowl use days are 172,900 for the Putah Creek Sinks Site; 2,650 for the Yolo Causeway Site; and 5,980 for the Davis Site. Average annual number of fledglings would increase by 2,630 at the Putah Creek Sinks Site; three (3) at the Yolo Causeway Site; and 30 at the Davis Site. The total increase, for all sites, in peak potential winter waterfowl use days and average annual number of fledglings would be about 281,530 and 2,660, respectively.

A total of about 198 species of resident and migratory birds could benefit from the restored habitat through provision of feeding and resting areas. Besides waterfowl, these include wading birds, shorebirds, other water birds, and upland birds. Additional species of fish (12 anadromous and 53 resident), mammals (45), amphibians, reptiles, and both terrestrial and aquatic invertebrates could benefit from the project.

Rare, threatened, and endangered species would be expected to benefit, either directly or indirectly, as a result of the proposed project.

In addition, the proposed project would increase the variety of habitats present. Each site, with its mixture of high value habitat types, would contribute to the diversity of the regional landscape. The restoration project would make an important contribution by increasing biological diversity at the species, ecosystem, and landscape levels.

Restoration of habitat for the benefit of fish and wildlife would improve other wetland functions, providing less direct, but important, benefits to fish and wildlife. Among these are water quality improvement and sediment stabilization functions. Seasonal and permanent wetlands would purify the water passing through them by removing and breaking down natural and artificial pollutants. Improved water quality would benefit resident or visiting animals at the sites, as well as those residing downstream.

While not a project purpose, recreation benefits would accrue from restored habitat and increased fish and wildlife visitation and production. The aesthetics, or overall visual richness, of wetlands contribute to their visitation by humans. There is considerable public interest in using these sites as educational destinations for public and school tours. The proposed restoration work would create opportunities for nature study (photography, bird watching, public education, and research), hunting (mainly waterfowl), and fishing.

CHAPTER III - UPPER MISSISSIPPI RIVER SYSTEM ENVIRONMENTAL MANAGEMENT PROGRAM (UMRS-EMP)

In 1978, Public Law 95-502 authorized the Locks and Dam 26 Replacement Project (with one 1200-foot lock) and directed the Upper Mississippi River Basin Commission to prepare a Comprehensive Master Plan for the Management of the Upper Mississippi River System. The Master Plan was completed on January 1, 1982; it recommended a second lock, 600 feet in length at L&D 26, and an environmental management program with an initial 10-year timeframe. The second lock and the Environmental Management Program were authorized for implementation by the U.S. Army Corps of Engineers by P.L. 99-88 in 1985 and P.L. 99-662, the Water Resources Development Act (WRDA) of 1986, Section 1103.

A "General Plan" for implementation of the UMRS-EMP was completed by the North Central Division, U.S. Army Corps of Engineers, in January 1986. The U.S. Fish and Wildlife Service, Region 3, and the five affected states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin) participated in plan development through the Upper Mississippi River Basin Association.

In October 1990, the Water Resources Development Act of 1990 was signed into law (P.L. 101-640). Section 405 of the Act provided for modifications to Section 1103 of P.L. 99-662, which in essence extended the authorization period for an additional five (5) years. Therefore, the UMRS-EMP is authorized for a 15-year period through 2002.

The UMRS-EMP is designed to protect and balance the resources of the Upper Mississippi River Basin and guide future river management. The UMRS-EMP has five (5) authorized elements: 1) Habitat Rehabilitation and Enhancement Projects; 2) Long-Term Resource Monitoring; 3) Recreation Projects; 4) Economic Impacts of Recreation Study; and 5) Navigation Traffic Monitoring. These elements are briefly described in the following paragraphs.

Habitat Rehabilitation and Enhancement Projects (HREP): HREP are proposed by states and the U.S. Fish and Wildlife Service, and are engineered and constructed by the Corps of Engineers. Most of these projects are designed to counteract side channel and backwater sedimentation. The projects typically involve dredging and alteration of flow patterns by structures, construction of enclosed levee systems with facilities for water level control, or island construction.

Long-Term Resource Monitoring (LTRM): LTRM will provide for more informed management of the UMRS-EMP, and is being implemented by the U.S. Fish and Wildlife Service with strategic oversight and funds transferred by the Corps of Engineers.

Recreation Projects include projects designed to enhance user access to the river and increase recreational opportunities related to the river. Although recreation projects are an authorized element of the UMRS-EMP, they are not being funded due to a low Federal priority.

An **Economic Impacts of Recreation Study** has estimated recreation use and expenditures for selected river-dependent activities in the UMRS-EMP by Corps District. Federal management decisions affecting the navigation project and Federal lands will be able to better consider the economic effects of consequent changes in recreational use.

Navigation Traffic Monitoring will help assure that the navigation system will be ready to meet the demands of the future and that expansion of navigation capacity will be part of a balanced approach to UMRS-EMP management.

Congress placed federal management responsibility for the program with the Corps of Engineers. In implementing the program, the Corps actively coordinates with the U.S. Department of the Interior, the Upper Mississippi River Basin Association, and the five states of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.

The North Central Division of the Corps of Engineers manages the program and is guided in its policies by the Office of the Chief of Engineers. Three local Corps of Engineers Districts: St. Paul, Rock Island, and St. Louis manage the habitat projects within their boundaries and work directly with states on individual projects.

The Department of Interior is a program partner through the involvement of two (2) agencies. The U.S. Fish and Wildlife Service is fully involved in habitat project planning. The five states of Illinois, Iowa, Minnesota, Missouri and Wisconsin and the Fish and Wildlife Service actively screen, recommend, and participate in developing habitat projects. Some projects involve state and local cost sharing with the federal government, further emphasizing the partnership approach of the EMP.

The National Biological Service, also of the Department of Interior, administers the Long Term Resource Monitoring Program (LTRMP). Purposes of the LTRMP include monitoring trends and impacts of the river with respect to selected resources, developing useful products for application to river resource management decisions, and maintaining river information databases. Six field stations, staffed by state personnel, are located along the river conducting trend data collection.

BAY ISLAND, MARION COUNTY, MISSOURI
Rock Island District

Location: The Bay Island complex is located on the Missouri side of the Upper Mississippi River between River miles 311 and 312, approximately one (1) mile north of Hannibal, Missouri. This complex encompasses approximately 650 acres of aquatic, wetland, and terrestrial habitat.

Resource Problems: The quality, extent, and diversity of this area's wetland habitat are rapidly decreasing. The migratory waterfowl and other wetland species which currently depend upon and utilize this habitat type for resting and feeding, as well as reproduction and brooding, are being adversely affected by its declining availability. Pool 22 and its environs currently lack sufficient wetland habitat to maintain the levels of waterfowl, shorebird, and furbearer use previously experienced in this area. Prior to establishment of the extensive system of agricultural drainage districts adjacent to the pool, prime forested wetlands were readily available throughout the area during annual migrations. Recognition of an ongoing loss of quality wetlands along this reach of the river prompted the development of the Bay Island project for waterfowl enhancement.

Objectives: The following design objectives have been established for this project:

- Provide controlled water levels over forested and non-forested areas during migration periods
- Increase mast tree dominance
- Increase total wetland values for migratory waterfowl as described by a Habitat Suitability Index (HSI) and resultant changes in Habitat Units (HUs).

Management Measures: One part of the chosen alternative is the construction of two (2) Waterfowl Management Units (WMUs) adjacent to one another. This would provide over 400 acres of manageable wetland area. The upper unit of approximately 240 acres would be forest-dominated, while the lower 165-acre unit would be primarily open. The two (2)-unit design will provide tremendous habitat diversity to the benefit of migratory waterfowl, shorebirds, furbearers, and other wetland species. Earthen perimeter levees four (4) to six (6) feet in height will delimit the WMUs. A 6,000-gpm pump station will be constructed adjacent to Ziegler Slough for pumping water into the units. Three (3) stoplog structures placed within the levee system will allow for independent water level maintenance within the two units, thereby assuring habitat appropriate for the targeted species during peak utilization periods (specifically, spring and fall migration seasons). Dewatering of the units will be by gravity flow through the channels created during levee construction.

Cover management. Another part of the chosen alternative consists of planting of mast tree species, clearing and passive vegetation management, and clearing and active vegetative management. This was selected due to its potential to increase the wetland habitat value of the project area as determined by application of Wildlife Habitat Appraisal Guide (WHAG). Establishing pin oaks as the dominant species on 30 acres within the confines of the forested WMU was found to provide the

greatest Habitat Unit (HU) return by diversifying the existing bottomland monoculture and providing valuable food resources for wood ducks and other wildlife species. Mast tree plantings associated with this project will consist of selectively thinning 20 acres of pin oaks in the north WMU and planting 10 acres of pin oaks in the cropped areas of the south WMU. State and district foresters recommended the pin oak planting sites.

Water Control Plan. The selected operation water levels are those that maximize the area with water less than two (2) feet deep. Migratory waterfowl, in particular dabbling ducks, require water depths of 12 to 18 inches for access to food plants. The selected water surface elevations represent maximum levels for design purposes; actual operation levels may be lower if desired.

Water Source. To accommodate WMU management strategies, a minimum pumping capacity of 6,000 gpm is required. (The possibility of using wells in lieu of a surface intake pump also was investigated. To achieve a pumping rate of 6,000 gpm, a minimum of three (3) wells would be required. This would not be as cost effective as a single-surface intake pumping unit.)

Pump Station. The pump station will be provided with a 6,000-gpm submersible propeller-type pump. The pump has the capacity to fill the forested unit in 15 days and fill both units in 23 days total. The pumps will be housed in a vandal-resistant cast-in-place housing. The intake entrance will be equipped with a trash rack. Underground electrical power will be provided to the site, and all necessary electrical equipment will be located on an overhead platform in the vicinity of the pump station.

Water Control Structures. Operation of the WMU's will require the construction of three (3) concrete stoplog water control structures. The perimeter levee water control structures are sized to preclude the need for an armored levee overflow section. The perimeter levee water control structures will have four (4) 5-foot deep log bays. All of the water control structures will have a steel grate deck for vehicle passage. For the perimeter levee, 54 cubic yards of concrete will be used and the weir length will be 20 feet. For the intermediate levee, 40 cubic yards of concrete will be used and the weir length will be six (6) feet.

Levee. From a flood protection standpoint, the proposed perimeter levee will provide slightly more than a 2-year level of protection. To minimize scour potential, the perimeter levee profile parallel to the Mississippi River is sloped upstream to provide for gradual overtopping during flood events greater than two (2) years. Embankment fill for the perimeter levee will consist of 55,000 cubic yards, length of 19,194 feet, top width of 10 to 12 feet, and side slopes of 1V on 4H. For the intermediate levee, there will be embankment fill of 10,165 cubic yards, a length of 4,800 feet, top width of 10 feet, and side slopes of 1V on 4H.

Levee Borrow. Borrow from the perimeter levee and intermediate levee will come from adjacent ditch excavations or scraped from adjacent excavations. These ditches will serve as an internal drainage system for the WMU's and facilitate the water control plan.

Costs: Total estimated cost for this project is $1,075,000 Dec. '89 P.L. ($1,247,000) with estimated annual operation, maintenance, and rehabilitation costs of $9,400 ($10,904).

Outputs/Benefits: Interagency application of the WHAG methodology determined that potential improvement of 360 percent for migratory waterfowl is possible for this project site.

Potential enhancement of the project area resulting from full implementation of the selected project features will include:

- Increasing by over 400 number of acres over which have reliable water level control
- Increasing project area's existing total wetland value of 99 HUs by more than 420 HUs
- Establishing 30 acres dominated by selected mast trees species

The project design selected is to provide habitat benefits for a minimum of 50 years.

BROWN'S LAKE, JACKSON COUNTY, IOWA
Rock Island District

Location: Brown's Lake, a 453-acre backwater complex, is located approximately 10 miles south of Bellevue, Iowa, on the Iowa side of the Upper Mississippi River and is located in Pool 13.

Resource Problems: Because of sedimentation problems, the area has gone from a lake of six (6) feet deep in the 1930s to a 6- to 18-inch-deep marsh complex. Sedimentation has continued with associated water quality degradation, which will increase the frequency of winter fish kill and will negatively impact a historically important migratory waterfowl, fishery, and furbearer area.

Objectives: The objectives for this project are the following:

- Retard the loss of fish and wildlife aquatic habitat by reducing sedimentation in the Upper and Lower Brown's Lake
- Improve water quality for Upper and Lower Brown's Lake by decreasing suspended sediment concentrations and increasing winter dissolved oxygen concentration
- Increase fish habitat in Upper and Lower Brown's Lake by dredging
- Increase fish diversity by providing varied water depths
- Increase habitat available for wintering fish by providing deeper water areas
- Increase bottomland hardwood diversity by increasing selected elevations and reducing frequency of flooding for such hardwoods

Management Measures: The selected plan consists of the construction of a deflection levee, water control structure, side access channel excavation, and lake dredging. These management measures are described in the following paragraphs.

Deflection levee - built to a 50-year flood event. The levee would function as a water deflection feature to prevent continuous flow-through and subsequent sedimentation during Mississippi River flood events. The levee will be built parallel to the Mississippi River approximately 200 feet from the shoreline. The levee will start adjacent to an existing levee and extend approximately 3,500 feet. The average height will be approximately eight (8) to 10 feet. The levee will be built where the river levels are low with conventional construction equipment using adjacent borrow sites. Side slopes of the deflection levee will be 1V on 3H. A turnaround structure will be constructed at the end of the levee. Riprap will be placed at this location for protection from floodwater erosion. A riprapped depressed section of the deflection levee also will be constructed to allow floodwaters to overtop the levee.

Water control structure - will connect the proposed deflection levee with the prementioned existing levee which will limit the amount of water entering Upper Brown's Lake. When water levels from the Mississippi River rise with heavy sediment bedloads, the gatewell structure will be closed to prevent such flow from entering Upper Brown's Lake. The gates will remain closed with flows deflected from direct entrance into the Brown's Lake unit if the levee is overtopped. This structure will consist of four (4) slide gates, each five (5) by five (5) feet, with individual operating systems. Stems should be stainless steel to ensure long-term maintenance-free use. The slide gates will operate against a one (1)-foot head differential. The concrete of the structure will provide additional dimension to allow future installation of sluice gates against differential head of approximately 15 feet.

Existing inlet channel - will be improved. The purpose of this modification is to restrict debris and bedload sedimentation from reaching the new water control structure and Brown's Lake by reorienting the mouth downstream rather than the present upstream. Excavation could be performed by either land-based or floating plant dragline or clamshell. Material will be side cast upstream and downstream of the modified entrance to provide additional debris deflection and service access to the entrance. Finished side slopes of 1V on 4H for the excavated material, along with immediate seeding, should stabilize this area against flood erosion.

Side channel excavation - will be performed adjacent to the existing levee. The centerline of the proposed excavation will be approximately 115 feet from the centerline of the existing levee. Excavation could be performed by either land-based or floating plant dragline or clamshell. Material will be side-cast on the river side of the existing levee to provide additional levee sections, stability, and future borrow.

Lake dredging - will be performed to ensure a minimum depth of seven (7) feet below flat pool. Occasional deep holes, approximately 20 feet in depth, will provide diversity.

Terrestrial dredged material disposal sites - will be replanted with species such as swamp white oak, pin oak, northern pecan, and shell bark hickory after sufficient drying and consolidation. Seedlings of two (2) to three (3) feet in height are proposed. Trees should be placed approximately one (1) tree per 100 square feet and placed in rows to facilitate maintenance mowing during the initial years of tree establishment. Lack of maintenance during these years will result in these trees being taken over by volunteer vegetation/trees. Herbicides should be used during the maintenance period to assist seedlings in competing against volunteer herbaceous species. After construction, the disposal site must consolidate/dry before tree planting. Fall planting should be used to avoid flooding damage and allow planting during normal dormant stage.

Other Management Measures Investigated:

Alternative A - No Federal Action - This would consist of no Federal funds being provided to meet the project purposes. State and local funds would be required to restore and enhance aquatic habitat. This alternative did not meet the rehabilitation and enhancement objectives for this project.

Alternative B - Basic Development Plan - This was the chosen alternative described above.

Alternative C - Full Expansion Plan - This would include the same features as described in Alternative B, but with the following increased features: additional 500,000 cubic yards of lake dredging; new disposal site; extend deflection levee forming a complete ring levee around the entire Upper and Lower Brown's Lake; and perform existing side channel access cleanout and debris removal. This was eliminated due to economic constraints.

Alternative D - Upland Erosion Control - Construction of upland erosion control facilities and management to achieve sound soil conservation practices would prevent upland sedimentation from entering Upper Brown's Lake from the Smith's Creek watershed. This would involve the installation of approximately 16 grade stabilization structures and upland land treatment which would consist of 580 acres of contour strip cropping; 94 water and sediment control basins; 34,500 feet of terraces; 411 acres of conservation tillage; and 19 small grade stabilization structures. This alternative is being pursued as a future, separable element of the Brown's Lake project. This timeframe will allow the proposed Brown's Lake features to be constructed and be evaluated for overall sediment reduction.

Costs: The estimated project cost is $2,873,000 Jun. '87 P.L. ($3,619,980) with an estimated annual operation and maintenance cost of $11,260 ($14,188).

Outputs/Benefits: The chosen plan will provide a commensurate increase of habitat rehabilitation and enhancement consistent with estimated costs.

BUSSEY LAKE, CLAYTON COUNTY, IOWA
St. Paul District

Location: Bussey Lake is located immediately upstream of L&D 10 on the Iowa side of the Upper Mississippi River. It is a backwater lake located in lower Pool 10 on the west (right descending bank) side of the river, approximately one (1) to two (2) miles upstream of L&D 10. The project area is within the Upper Mississippi River Wildlife and Fish Refuge. Immediately adjacent to the lake is the city of Guttenberg, Iowa. The next closest major city is Dubuque, Iowa, about 30 miles downstream.

Resource Problems: Since the construction of the lock and dam system in the 1930s, sedimentation has been the prime factor influencing habitat changes in Bussey Lake. Sedimentation has been a limiting factor for fish, because of the increasing lack of deep water for thermal refuge. The shallow depths in the lake also have encouraged the growth of aquatic vegetation, which has further reduced fish productivity. In addition, there is concern that decreasing depths and increasing vegetation could result in periods of depressed oxygen levels during the summer and winter.

Objectives: Habitat diversity can be increased in the lake by:

- Reducing aquatic plant cover in the lake and increasing the amount of vegetative and or nonvegetative edge
- Increasing the variety of water depths in the lake
- Increasing the diversity of substrate types in the lake

Management Measures: The selected plan would involve dredging of approximately 270,000 cubic yards of material to create about 12,000 linear feet of channel in Bussey Lake. The channels would have 75-foot bottom widths with 1V on 6H side slopes. The majority of the channels would be dredged eight (8) feet deep. In a few locations, dredged channel depths would be six (6) and seven (7) feet to create more bathymetric diversity while keeping dredged volumes at a minimum. This includes a more shallow area in the vicinity of the spring on the west side of Bussey Lake and a gradual decrease in elevation in the channel along Abel-Esmann Island as it approaches the controlled culvert. At the spring, a 3.5-acre (475 by 325 foot) area would be dredged to a depth of six (6) feet. This area is being dredged to provide a wider band of slightly deeper water in the vicinity of the spring. The channel along the east side of the lake would have a 1,000-foot reach at a depth of six (6) feet, extending from the culvert southward. This would be followed by a 1,200-foot reach that would be seven (7) feet in depth. In addition to providing habitat diversity, the primary purpose of this stretch of channel is to carry flow from north of the culvert into the lake during periods when sedimentation is not considered to be a problem.

Disposal - The material dredged from Bussey Lake would be used at the Guttenberg waterfowl ponds located southeast of Bussey Lake, immediately below the Lock and Dam 10 dike. About 115,000 cubic yards of the dredged material would be used to elevate and level the bottoms of the three (3) existing moist soil units totaling 35 acres in size. Two (2) smaller ponds would be broken to expand the present pond system slightly. This would allow for the use of an additional 10,000 cubic yards. The bottom elevation of the ponds moist soil unit would be raised two (2) to three (3) feet. The moist soil units would be managed for waterfowl food production, and raising their bottom elevation would increase their drainability.

The remaining 145,000 cubic yards of material would be used to create one new moist soil unit, 15 acres in size, immediately to the west of the present system. The elevation of this new pond would be the same as for the upgraded exiting dikes. The top width would be 10 feet with side slopes of 1V on 3H on the interior of the ponds and 1V on 5H on the outside. The dikes for the expanded pond could be constructed of material from the interior of the site and/or from the local slough, located about 3,000 feet to the southwest. A sandbar has formed, nearly blocking the mouth of this slough. Removal of this material would enhance the fishery habitat provided by the slough.

With the construction of a fourth pond, additional features have been recommended in order to allow maximum operating flexibility of the ponds. This would consist of the addition of a control structure between ponds 2 and 4. A third controlled outlet would be placed at the lower end of the new pond. This would allow water to be drained into another slough. Besides increasing the avenues of delivery from the ponds, the intake pipe would be redesigned. Currently, water entering the ponds is controlled by a knife valve in a manhole located along the intake pipe approximately 100 feet downstream from the Lock and Dam spillway. This would be added to this pipeline at this point to allow independent operation of some of the ponds. The new pipe would extend 950 feet to the west, outletting into pond 2.

Control Structure. A gated control structure would be constructed on the upstream end of the 6-foot-diameter culvert which extends through the Abel-Esmann Island causeway. The gate would be installed onto the existing corrugated metal pipe. Installation of the control structure will entail construction of a sheet pile/concrete headwall to support the proposed slide gate structure. The gate can be raised and lowered by a stem/wheel system. Access to the gated control structure, for the purpose of operation, would be from the top of the road. Any exposed culvert from the road to the control gate would be covered with fill. The placed fill would slope down on either side of the culvert at 1V on 3H. A fence would be installed at the headwall as a safety and security feature.

Costs: Total direct construction cost of the selected plan for Bussey Lake is $1,684,600 Apr. ‘90 P.L. ($1,919,760) with an estimated cost of $43,300 ($49,362) for the control structure. Average annual operation and maintenance costs for the entire project are estimated to be $2,500 ($2,850).

Outputs/Benefits: The habitat changes at Bussey Lake that would occur as a result of the project include the establishment of 29 acres of deeper water with reduced vegetation growth, the creation of approximately 27,000 linear feet of open water/vegetation bed edge, an increase in the bathymetric diversity in the lake, and the ability to prevent sediment and contaminants from entering Bussey Lake via Buck Creek. At the Guttenberg waterfowl ponds, 35 acres of existing moist soil units would be improved to enhance management capabilities. An additional 15-acre moist soil unit would be created.

FINGER LAKES, WABASH COUNTY, MINNESOTA
St. Paul District

Location: Finger Lakes are located on the Minnesota side of the Mississippi River Pool 5 immediately downstream from the dike for Lock and Dam 4. The project area is within the Upper Mississippi River Wildlife and Fish Refuge. The closest major metropolitan areas are Minneapolis and St. Paul, Minnesota, which are 70 miles northwest, and LaCrosse, Wisconsin, which is 50 miles to the southeast.

Resource Problems: Prior to the construction of Pools 4 and 5 lock and dam systems, the study area consisted of running sloughs, marshes, and floodplain forests. At that time, two (2) defined, continuous flow channels existed. Following inundation, water levels rose, converting the marsh/slough areas and part of the floodplain downstream of the dam into the five Finger Lakes and connecting sloughs that are in existence today. On the west, upstream of the Lock and Dam 4 system, a large body of water was formed, referred to as Peterson Lake. As part of this system, a 5,500-foot-long dike was constructed which extends from the Minnesota main shoreline to the spillway of the dam. This dike has a top elevation equivalent to the 100-year flood event. Upon completion of the entire lock and dam system, the area upstream of the dike was essentially eliminated as a direct water source to the downstream lakes. The dike has not been overtopped since it was built. Fresh flows have been able to directly enter all five lakes only during high flows on the Mississippi River and/or the Zumbro River when water passing through the dam flowed back into the lakes. Like the rest of the Upper Mississippi River system, the project area experiences annual high water which occurs most frequently in March and April. The primary source of floodwaters is spring snowmelt combined with the increased precipitation.

In the mid-1960s, the lack of fresh flows into the area downstream of the dike was improved somewhat with the placement of a single culvert (48-inch corrugated metal pipe) through the dike. It is the only source of fresh water into Finger Lakes at low river stages. Depending on local flow conditions as well as beaver activity in the area, the water entering one lake may also spread into two (2) other lakes. One lake is currently isolated from the system because of beaver activity which has blocked the outlet from the lake. The five (5) Finger Lakes comprise a 132-acre backwater lake complex. Average water depths range from two (2) to four (4) feet. Shallow depths, combined with limited flow through four (4) of the five (5) lakes, result in some areas having periods of dissolved oxygen deficiency which limits productivity and population diversity. These conditions occasionally result in fish kills, particularly in winter.

Objective: The overall objective for Finger Lakes is to increase the amount of available fish habitat on a year-round basis in the Finger Lakes by stabilizing dissolved oxygen levels of greater than 5 mg/l. This would alleviate current problems in the Finger Lakes complex.

Management Measures Considered: To meet the project objectives, it is imperative that the project be designed with enough flexibility to ensure the ability to meet the stated goals under a variety of conditions. Due to blocking problems, freezing, and design assumptions, it appeared advisable to increase the required culvert size to near 50 cfs to maintain operational flexibility. Several management measures were considered for this study area which included a no-action alternative, as well as several structural solutions. These management measures are discussed in the following paragraphs.

Siphon. The lifting of water over the dike into the downstream lakes by siphonic action was considered. There was a perceived potential for a major reduction in construction costs with considerable difference in operation and maintenance costs. This could be the result because no dewatering should be required for this alternative during construction. The pipe would need to be buried as it crosses the dike, but not below the water line as would be needed for a gravity flow culvert system.

A literature search revealed no prior experience with siphons as proposed in this project. Generally, siphons such as this are used only to reduce the apparent head seen by a pump and in this situation, are not capable of running without the pump in operation. Air-regulated siphonic spillways are sometimes used in low-head applications. In these instances, however, they are used to increase flow over a weir in a flood event and not to continually transport water over a dike. The following describes the risks and uncertainties of using siphons.

- A siphonic line must be essentially airtight and remain so for the life of the project. Once the seal in the pipe is broken, the siphon no longer functions effectively. The frequency of this occurring should be minimal. However, since the pipeline for the siphon would be buried where it crosses the dike, any leakages in the pipe itself could be costly and inconvenient to repair.

- If a single, larger pipe were used to provide siphonic flows to an individual lake, it would be very difficult to design an operating system that would consistently be able to provide water over a wide range of flows.

- The entrance to the siphonic system would be placed several feet below the low control pool elevation. With this system, although the siphon would still be susceptible to plugging, the frequency of this occurring should be reduced with the more deeply submerged entrance. Because the pipe would be in deeper water, however, it would be more difficult to clean once it became plugged.

- Bends in the pipe would make visual inspection very difficult and help trap any debris brought up inside the pipe.

- As with a culvert, partial blockage of the siphon pipe would reduce the efficiency of the operation. Unlike a culvert, blockage of greater than 50 percent of the opening would likely result in loss of the siphonic action.

- In winter, the siphon should function as well as in the summer once the system was operating. However, if the prime were lost, restarting could be difficult because of the freezing conditions that exist at the interface of the air and water within the pipe.

- Because the siphon must be primed, more human intervention would be required.

The only potential first cost savings with this alternative, as compared to a culvert alternative (described later) would be the dewatering costs. Currently, this cost savings is estimated at approximately $20,000 ($22,800) per culvert. This savings would be more than offset by pump, gate, valve, and air relief valve installation, and design costs. With regard to future O&M, although pipe cleanout would probably be less frequent with this type of design (and other potential problems mentioned above that could occur with a siphon system would be rare), the actions required to maintain a functional system would be much more difficult and expensive. For these reasons, the siphon system was dropped from further consideration.

Culverts. Four (4) different culvert designs were considered for getting flow into the four remaining lakes. These are described in the following paragraphs.

- Culvert Alternative 2A - consisted of culverts through the dike into three (3) of the lakes. A ditch/culvert system running from the main channel of the Mississippi River into the first lake would be constructed immediately below Lock and Dam 4 to provide flows to this lake. This alternative was dropped due to insufficient head differential between the Mississippi River and this lake.

- Culvert Alternative 2B - the flow through the existing culvert into Lower Peterson Lake would be split among all five Finger Lakes by means of a network of pipes. All outlets would be controlled by slide gates. The estimated total project cost for this alternative was $888,000 ($1,012,320).

- Culvert Alternative 2C - consisted of a single gate well structure located in the dike north of First Lake near the main channel. Flow would enter the gate well via a single culvert and would be distributed to First and Second Lakes via two (2) culverts exiting the gate well. Clear Lake and Third Lake would be supplied with flows by single culvert systems, installed immediately upstream of each of these individual lakes. Using the 50 cfs flow criterion, the estimated cost of supplying all four (4) lakes was $790,000 ($900,600).

- Culvert Alternative 2D - a culvert or ditch would connect Lower Peterson Lake and Clear Lake, in place of a culvert system through the dike into Clear Lake. The remaining three lakes would be supplied by a system that was selected as the best of the remaining viable alternatives presented. Field measurements have shown little or no head differential between Lower Peterson Lake and Clear Lake. Therefore, this alternative was dropped from further consideration.

Wells. There is approximately 200 to 300 feet of Mississippi River alluvium over Cambrian and Precambrian rock. The bedrock stratigraphy in the river valley is as follows:

Ironton-Galesville aquifer (may be eroded)
Eau Claire sandstone (not a good water producer)
Mt. Simon-Hinckley aquifer (typically produces flowing wells)

Flowing wells are known to be present in the Kellogg area, although no recent data are available. These wells typically have been in the 350-gallons-per-minute flow range. Based on this information and general knowledge on wells, a very optimistic flow from a typical single 6-inch-diameter well would be less than one (1) cfs (1 cfs = 449 gpm). A more reasonable estimate would be 200 gpm (0.45 cfs). There would be problems associated with drilling into an artesian system. An estimated depth of approximately 500 feet would be required to reach a flow in the 200- to 400-gpm range. The approximate cost of the drilling operation was estimated to be $29,000 ($33,060) per well, which does not include mob and demob, access, and aeration structure costs. It would take numerous wells to reach the 50 cfs design flow. Because of high costs of implementing to full project, as well as the inability to assure that the drilling operation would be successful, this alternative was dropped from further consideration.

Chosen Management Measure: Culvert Alternative 2C was chosen because it was the least costly of the other alternatives. This alternative consists of the construction of three (3) separate gate well/culvert systems that would supply flows into the Finger Lakes. Clear Lake and Third Lake would have individual gate well/culvert systems located immediately upstream of each lake. Clear Lake would have a 36-inch-diameter reinforced concrete pipe extending 300 feet from upstream of the dike to a point beyond which water could flow by gravity into Clear Lake. Water running into this lake would exit the culvert into a wetland upstream of the main body of Clear Lake. No ditching would be required to bring flows directly into the lake from this point. Third Lake would also be supplied by a 36-inch-diameter reinforced concrete pipe. Because of the existing topography downstream of the dike in the vicinity of Third Lake, only a 170-foot-long culvert would be required to supply flows to the lake. The remaining two (2) lakes, Second and First, would be supplied by separate parallel culvert systems which would pass through a common gate well structure in the dike. The culvert to First Lake would be 42-inch diameter with an overall length of 350 feet. To supply flows to Second Lake, a 48-inch diameter pipe would be required, extending a distance of about 860 feet. Some ditching would be required at the entrance to the First and Second Lakes culvert in order

to assure that adequate flows would reach this system. Additional ditching may also be required at the culvert to assure proper flow to these two lakes. Material would be sidecast to create a berm next to the ditch.

Features that are common to all of the gate well/culvert systems include the control mechanism, erosion/scour protection, and debris control structures. Within each gate well/culvert system, a sluice gate would be installed to control flow into that particular lake.

Riprap is required for scour protection which would come from the existing quarries in the area. Fill for construction would most likely come from existing dredged material disposal sites in the area of the project.

Costs: The cost for this project using the 50-cfs-flow criterion to supply all four lakes was $790,000 May '90 P.L. ($900,600), with a total annual cost of $10,500 ($11,970).

Outputs/Benefits: The proposed action would improve 113 acres of aquatic habitat in the Finger Lakes complex by making this amount of habitat available as suitable fish habitat on a year-round basis. This number includes the culvert to Third Lake where 27 acres would be affected. This would result in increased productivity and diversity of the existing fish population.

LAKE CHAUTAUQUA, MASON COUNTY, ILLINOIS
Rock Island District

Location: Lake Chautauqua is located about 45 miles southwest of Peoria, Illinois. It lies within the Illinois River floodplain and is part of the Chautauqua National Wildlife Refuge. Lake Chautauqua is a 3,250-acre floodplain lake and wetland complex. The lake is formed by a nine (9)-mile perimeter levee and is divided into an upper and lower lake by a cross dike.

Resource Problems: Following the organization of the Chautauqua Drainage and Levee District in 1916, the area was drained and leveed for farming. However, recurrent flooding led to the abandonment of the area in 1926. In 1936, the F&WS purchased the Levee District and Lake Chautauqua became a part of the National Wildlife Refuge System. The levee was retained for refuge water level control purposes. In 1969, a cross dike was constructed to divide the lake into upper and lower management units.

The lakes have since deteriorated due to frequent flooding and sedimentation. Suspended sediments carried in by floodwaters impede submergent and emergent plant growth by decreasing light penetration and creating a soft, flocculent lake bottom. Since 1978, there has been a documented, long-term decline in both the annual fall peak number of ducks in the refuge and the total fall use days.

Objectives: The following objectives were identified for Lake Chautauqua.

- Increase submergent and emergent vegetation
- Create flowing side channel and deepwater slough habitat
- Reduce sedimentation

Management Measures Considered: Five plans were considered to meet the stated objectives. These plans are: 1) No Federal action; 2) improve water control; 3) construct barrier islands; 4) excavate flowing side channel; and 5) raise levee elevations.

Evaluations of the project alternatives were accomplished through the application of habitat evaluation assessment methodologies. Aquatic models developed by WES were used to evaluate existing aquatic and benthic resources and to quantify potential project outputs. The Wildlife Habitat Appraisal Guide (WHAG), a habitat assessment methodology designed by the Missouri Department of Conservation in cooperation with the U.S. Natural Resources Conservation Service (formerly the Soil Conservation Service), was used in the analysis of wetland and terrestrial habitats. The alternatives were evaluated on an individual and combined feature basis.

Management Measure Chosen: The construction of water control structures and side channel excavation was recommended and includes the eight (8) following features:

1) Raising approximately 3.8 miles of existing levee and cross dike to a 10-year level of protection

- Provide flood protection to a 10-year level
- Raising and strengthening cross dike and upper lake levee by excavating adjacent soil for placement as levee embankments
- Side slopes of cross dike 1V on 6H on downstream slope; 1V on 4H on upstream slope
- Perimeter levee slopes of 1V on 4H
- Length of the upper lake perimeter levee of 15,400 feet with crown width of 12 feet
- Embankment volume of 196,000 cubic yards and 2,400 tons of riprap
- Cross dike length of 4,950 feet with crown width of 15 feet; embankment volume of 121,000 cubic yards; permanent & temporary erosion matts of 1,500 and 6,000 square yards, respectively
- Crushed stone access road constructed using 1,600 tons
- Completed embankments seeded

2) Modifying an existing radial gate structure

- Raising the existing concrete sill four (4) feet with integral gated gravity openings
- Provide a 10-year level of protection and allow gravity drainage to existing sill elevation
- Approximately four (4)-foot-high concrete sill will be placed on the existing concrete sill to provide this equivalent protection
- Stoplogged openings, each three (3)-feet high by four (4)-feet wide, through this sill will be provided to allow gravity drainage of the upper lake to the existing gate sill elevation
- Total of eight (8) openings in combination with the pump station gates and upper lake gravity outlet were required to provide interior water levels with 0.5 foot of exterior river levels within seven (7) days of the river reaching a constant elevation
- Riprap (3,000 tons) will be placed around the structure to minimize erosion damage

3) Providing a pump station with 1,000-gpm capacity

- Concrete gated structure with 41,000-gpm capacity to provide the capability of 1) dewatering upper and lower lakes; 2) pump from river to upper and/or lower lake; and 3) connect the upper and lower lakes by gravity flow
- Required to have the flexibility to pump from both the upper and lower lakes and from the river to either lake to meet the management plan
- Pump station located at intersection of the cross dike and the perimeter levee
- Selected submersible pump will be a horizontal propeller type with 48-inch discharge tube, 200 feet long with a flap gate 48-inches diameter

- Two (2) slide gates - five (5) feet by five (5) feet each and three (3) trash racks with a 3-inch bar spacing
- Feature will use 620 tons of riprap

4) Providing gated gravity outlets for the upper and lower lakes

- Concrete gated structure with 60-inch diameter pipe/culvert, 140 feet long with a sluice gate/gatewell (5 feet x 5 feet) on the river side
- Provide the capability to: 1) gravity control/dewater the upper lake; and 2) allow river water supply to the upper lake
- Trash racks will be provided at both ends due to potential flow reversal and associated debris
- Structure will be enveloped with riprap (380 tons)
- New stoplog structure in the lower lake made of concrete with four (4) bays with a width of five (5) feet, for a total hydraulic opening of 20 feet; provide the capability to gravity dewater the lower lake
- Structure will also include riprap (155 tons)

5) Providing drainage channels to the pump station and gravity outlets

- In the south lake, which would entail excavating drainage channels/ditches, ensure gravity flow from the south lake to the proposed stoplog structure and pump station
- Typical channels will be approximately 35 feet in width and two (2) feet deep and 7,500 feet in length
- Total excavation volume of 29,500 cubic yards

6) Providing boat ramp for upper lake management purposes

- For the upper lake as a single-lane ramp with associated parking
- Provides lake access for management personnel and mitigates the loss of boat ramp usage of the south lake during drawdown period
- Boat ramp width will be 16 feet wide with 700 feet of access road

7) Constructing a side channel entrance closure structure

- Approximately 8,400 feet of side channel with a total volume of 183,900 cubic yards will be excavated
- Construction bottom width will be 35 feet with 1V on 2H side slopes and totaling 15 acres of surface area flat pool
- Deepwater slough area of 300 feet in length will be excavated with a total volume of 12,000 cubic yards with the same side slopes and construction bottom width
- Total surface area will be 0.7 acres

- Side channel entrance closure structure will encompass 800 tons of rockfill and 5,570 tons of riprap

8) Excavating a selected reach of side channel

Costs: The fully funded estimate of this project is $4,113,000 Feb. '91 P.L. ($4,606,560). Estimated annual operation and maintenance costs are $29,800 ($33,376) and estimated post-construction annual monitoring costs are $15,410 ($17,259).

Outputs/Benefits: This project will provide about 3,250 acres of manageable aquatic and wetland habitat and approximately 8,400 feet of flowing side channel. Migratory waterfowl habitat value will be enhanced by increasing the seasonal availability of reliable water, food resources, and resting, loafing, and nesting opportunities. Fisheries benefits will be accrued through the creation of off-channel, flowing water habitat and deepwater slough habitat.

PEORIA LAKE, PEORIA POOL, ILLINOIS - ILLINOIS WATERWAY
Rock Island District

Location: Peoria Lake is located between River miles 162 and 181 on the Illinois Waterway. A riverine lake encompassing 14,000 acres, it is subdivided into Upper and Lower Peoria Lakes by a natural constriction occurring at approximately River mile 166.5.

Resource Problems: Nearly 68 percent of Peoria Lake's volume has been lost to sedimentation since 1903. Shoaling has seriously impacted the lake's fish and wildlife habitat value. The existing depths are unable to maintain the dissolved oxygen levels necessary to support a diversity of fish species. In addition, Upper Peoria Lake is conducive to wind-fetch generated by wave action. Such wave action over the lake's shallow depths results in the resuspension of the upper flocculants, thereby increasing turbidity levels and reducing photosynthetic activity. Also, constant churning of the sediments prohibits consolidation. The resulting soft lake bottom is not receptive to aquatic plant rooting and survival. The lack of submergent and emergent aquatic vegetation throughout Peoria Lake is minimizing the area's ability to support historically documented fish and wildlife populations.

Objectives: The following objectives were determined for this project:

- Increase reliability of food production and resting area for waterfowl
- Increase diversity and areal extent of submergent and emergent vegetation for waterfowl
- Provide flowing side channel habitat

Management Measures: Multiple project sites, construction alternatives, and design configurations have been considered for the purpose of accomplishing the stated objectives. The selected plan of forested wetland management area, barrier island and flowing side channel are described in the following paragraphs.

Forested wetland management area - would consist of an area bounded and divided by levees which form controlled ponding units. Because it was desired to have ponding depths of approximately two (2) feet, a three-cell unit was designed to take advantage of the existing topography. Water will be pumped from a new pump station into one (1) cell and when ponded will allow to flow into the other cell and the same for the next cell. The stoplog structures in each of the cells will allow flexible and independent operation of each cell. The cells will be filled in an approximately 10-day pumping period, using a water supply of approximately 6,000 gpm. Water would be pumped from a surface intake pump station using a 30-horsepower submersible pump having a capacity of approximately 6,000 gpm against a total dynamic head of approximately 12 feet. Water will be pumped through a 24-inch concrete pipe into a discharge assembly. The purpose of the discharge assembly is to dissipate exit velocity and to prevent vandalism to the pipe.

The water control structures or stoplog structures (four 5-foot openings) consist of a concrete sill with concrete dividing walls and abutments that incorporate stoplog recesses. The hydraulic opening of these structures has been determined based on hydrologic simulation of Illinois Waterway flood events. The hydraulic opening size was finalized after a selected river event overtopped the proposed levees with approximately one (1) foot of head differential still remaining on the interior of the cells. This sizing method was chosen to minimize overtopping damage. The opening width in the water control structures is sufficient to allow the interior cells to rapidly fill such that at the overtopping point, the head differential between the exterior and the interior is approximately one (1) foot.

The river side of one of the cells embankment has been provided with a 1V on 6H slope to prevent high water wave erosion damage. All other embankment slopes are 1V on 3H which will facilitate levee maintenance. The top width of the levee is 12 feet in order to facilitate access to the stoplog structures and other operational requirements. The average height of the levee is five (5) feet.

Barrier island - would provide a protected, wave-free zone to promote establishment of an aquatic bed. Aquatic beds are virtually non-existent in Peoria Lake due to shallow water, soft sediment bottoms, high turbidity levels, and uprooting waves. Establishment of aquatic beds would provide both a food source and resting area for migratory waterfowl. The aquatic bed also would increase the existing wetland value for mallards by approximately 360 percent. The proposed barrier island will have an approximate 50-foot-wide crown, with an overall width of approximately 182 feet. The overall length will be 1.1 miles. The borrow depth will be 15 feet from flat pool and the width will require approximately 226 feet at the top, sloping to approximately 135 feet at the bottom of the borrow area. Mechanical excavation was chosen over hydraulic dredging because mechanical excavation would maximize sediment removal and be more cost effective, and excavated sediment material greatly promotes reestablishment of vegetation for habitat enhancement due to high nutrients. The volume of the embankment fill would be 482,000 cubic yards.

For bank stabilization, planting vegetation on the flattened slopes to prevent erosion was chosen over riprap on a geotextile fabric due to the difference in cost. Two (2) floating vegetated islands would have four (4) modules per island with a module length of 16 feet and width of eight (8) feet. The soil-filled modules will be planted with vegetation and anchored to allow full vertical movement from flat pool to the 100-year flood event. Floating islands are a natural phenomenon that occur in bogs and marshland over a wide geographic range. These floating mats of vegetation result from air trapped within the various parts of the plants, thus making the entire mass highly buoyant. These islands serve a variety of functions, from water quality improvements to habitat for wildlife.

Flowing side channel - to provide side channel aquatic habitat in Peoria Lake. Side channel habitat is one of the most productive aquatic habitats for fishery resources. The proposed side channel excavation is divided into two separate reaches, one reach being 2,250 feet long and the other being 1,300 feet long. Both reaches will have a bottom width of approximately 95 feet. Also, both reaches will be excavated for a clear water depth of seven (7) feet from flat pool. The construction will consist of multiple passes using a large clamshell bucket gently placing excavated material on both sides.

Tree plantings are proposed for the forested wetland management area, the barrier island crest, and the elevated embankments. There will be two (2) rock substrate beds. Each rock bed will consist of an approximate 2-foot thick rock blanket about 50 feet wide by 300 feet long. Each bed will be of specific gradations. One bed will be a 50:50 mixture of medium sand and gravel one (1) to three (3) inches in diameter. The other bed will be a 50 percent mixture of medium sand, 25 percent one (1) to three (3) inch gravel, and 25 percent cobble or rock (particles up to 10 to 12 inches in diameter). The more coarser-grained material should be in the higher velocity currents, whereas the finer-grained materials should be in the lower velocity currents.

Costs: The total fully-funded cost estimate for this project is $4,237,00 Feb ‘90 P.L. ($4,872,550).

Outputs/Benefits: Development of the selected plan will provide nearly 168 acres of manageable, forested wetlands; a 1.1-mile-long, 16-acre barrier island; restored flow through the East River side channel; and 3,300 square yards of submerged rock substrate habitat. This alternative will improve the existing aquatic habitat by approximately 200 percent.

PHARRS ISLAND, PIKE COUNTY, MISSOURI
St. Louis District

Location: This project area is located in Mississippi River Pool 24, about three (3) miles upstream from Lock and Dam 24. It consists of approximately 525 acres of Federal lands and water.

Resource Problems: The Pharrs Island complex illustrates a pervasive process in Pool 24 of water habitat conversion to land. As the lower (growing) end of Pharrs Island achieves a more stable configuration, it is anticipated that the island's non-forested wetlands will eventually disappear. During the period from 1972 to 1987, the conversion of water to land within this complex proceeded at a rate of three (3) acres per year. At this rate, all interior non-forested wetlands habitat would be expected to disappear from the project area during the next 50 years. This change represents a quantitative loss of habitat to both fish and wetlands associated wildlife species.

This complex is also affected by fluctuations in pool stage. These water elevations can fluctuate by a number of feet above and below normal pool stage, and for extended periods of time. A drop in water elevation can cause a drawdown action that lowers the utility of the island's shallow interior wetlands for fish spawning and rearing. These fluctuations can also impact the production of aquatic plants, and the availability of these plants as a food source to waterfowl.

In addition to acreage shifts, evidence of habitat degradation at this complex exists in the form of hunter blind counts. The number of blinds in the project have decreased from 51 in 1957 to 24 in 1987, a rate of nearly one (1) blind per year.

Objectives: The objectives for attaining the waterfowl goal for this project area are to:

- Decrease sedimentation into the island's wetlands
- Provide a means to control water levels on the island independent of river stage
- Increase reliable food production for waterfowl (particularly moist soil plant species)
- Increase total wetland values (i.e., habitat units) for migratory waterfowl

Objectives for the fisheries goal for this project area are to:

- Increase the quantity of river slackwater habitat
- Reduce the potential for backwater sedimentation
- Increase the photic zone
- Increase the available cover
- Increase the total habitat values for slackwater fishes

Management Measures: The project's management measures have been separated into two (2) phases for implementation - Phase I (backwater features) and Phase II (island features). Phase I has been constructed; construction of Phase II is contingent upon the availability of program funds.

Phase I Measures: To retard the deposition of sediment into the project area and to provide additional backwater habitat, a 10,200-foot long rock dike would be constructed. The upstream end of the dike is bull-nose shaped and then trails in a southeasterly direction to the downstream end of the project. The crown width of this dike is six (6) feet, the base width 46 feet with side slopes 1V on 2H. The dike was constructed entirely of grade "A" stone along the trail dike segment, but the bull-nose portion (approximately 6,750 feet long with an average height above river bottom of 10 feet) consists of an "A" stone exterior covering with a gravelly-red clay interior. The "A" stone provides protection from river currents, ice and debris; the gravelly red clay provides protection against sediment infiltration to the interior. The trail dike (3,450 feet long includes a 300-foot kicker device at the downstream end of the dike, and lies at an average height of 12 feet above river bottom) parallels rather than perpendicular to the river flow. Special seepage control was determined not to be needed.

To improve aquatic habitat cover within the new backwater area, 200 clumps of cedar trees over a 40-acre area would be weighted and suitably anchored to the shore to prevent movement. This is to increase the amount of fish cover from an existing <10 percent to >25 percent. To permit access to service boats, a boat pullover device would be provided.

Phase II Measures: To provide a means for controlling water levels on the island, about 8,255 feet of levee would be constructed. This levee would supplement existing segments of natural levee along the island's perimeter. In addition to water control, the levee system would also help provide sediment protection to the island. The new levee would consist of a long lower island segment (3,950 feet long), two (2) intermediate length mid-island segments adjacent to the navigation channel, (an upstream segment of 1,760 feet long, and a downstream segment of 1,495 feet long), and a number of smaller slough closure segments (totaling 1,050 feet) along the upper island. A 100-foot-wide vegetative buffer would be included between the longer levee segments and the island's shoreline to safeguard eagle perch sites. This would be about 10 acres of planting of mast trees such as pin oaks and pecan trees.

About 43 acres of borrow sites would be required just landward of the levee construction zones. These borrow sites would serve as future non-forested wetland management areas. Forty-six (46) acres of younger-aged tree vegetation removal from lower elevation areas would be accomplished to further expand non-forested wetland habitat.

In addition to the levee, a 36-inch culvert drain with a 60-inch diameter gatewell-protected sluice gate with an 18-inch concrete base for protection, and a 15,000-gpm portable pump would be provided for water control on the island. Installation of the gated drain would be accomplished using

a cofferdam (later removed); this drain would be used primarily for the discharge of interior waters and for the input of water up to normal pool.

To facilitate the input and output of water, five (5) segments of interior island slough would be dredged for a combined total of 12,000 feet with a width of 25 feet. Three (3) 500-foot segments along this ditch system would be opened to a bottom width of 50 feet. Approximately 10 acres of forest, distributed between two interior island locations, would be cleared and the site perimeter bermed. These areas would be used to contain the slough dredged material.

In addition to its substantial habitat gains, the project is innovative. The levee system design is an attempt to work with the river system to achieve a low-cost means of increasing habitat values. The design recognizes and takes advantage of the river's own capacity to create levees. The river's natural levees need only be supplemented with sections of new levee (built to a similar elevation) to provide a biologically beneficial means of controlling water levels and sediment flow. Perhaps even more innovative is the dike design concept. This structure provides a means of creating critical backwater habitat where non presently exists. This technique may become increasingly valuable in the future as more and more backwaters become smothered with sedimentation. This method of backwater development is an attractive management alternative to deepwater dredging, which is far more costly, and in the long term is far less effective.

Costs: The total project cost is $2,783,250 Oct. ‘89 P.L. ($3,228,570)with an estimated annual operation, maintenance, and rehabilitation cost of $19,563 ($22,693), and an estimate of performance evaluation monitoring costs of $6,000 ($6,960) per year.

Outputs/Benefits: The project should eliminate approximately 96 percent of the future input of sediment into the island complex that results from the frequent lower elevation flood events. The overall contribution of this project to waterfowl, as represented by the mallard duck, would be a net gain of 118 average annual habitat units (AAHUs) and for large slackwater fish, a gain of 51 AAHUs.

POOL 8 ISLANDS, VERNON COUNTY, WISCONSIN
St. Paul District

Location: The project area is within the Upper Mississippi River Wildlife and Fish Refuge and is located in Vernon County, Wisconsin, and Houston County, Minnesota. The nearest communities are Brownsville, Minnesota, which lies immediately upstream, and Stoddard, Wisconsin, which is nearer the downstream end of the study area. The closest major city is LaCrosse, Wisconsin, located 15 miles to the north. The study area covers approximately 5,000 acres in lower Pool 8.

Resource Problems: Since inundation in the 1930s, erosive forces have caused a dramatic decrease in the size and number of islands located in the lower portion of Pool 8. This erosion has led to a loss of not only terrestrial habitat, but also the protected littoral zone associated with these islands. It has also contributed to increased sediment inflow into the backwater areas and magnified negative effects of currents and waves on backwater sediments and aquatic vegetation.

Objectives: The stated objectives for this project are to:

- Reestablish 15 acres of stabilized islands
- Reestablish a grass/shrub/herbaceous vegetative cover on the islands in order to provide secondary wildlife benefits (especially waterfowl nesting)
- Increase Sheltered-Shallow Habitat by at least 100 acres, and Sheltered-Deep Habitat by a minimum of 30 acres
- Reduce 75 percent of main channel flow into the project area to decrease sediment loading and thereby reduce backwater aquatic habitat loss from sedimentation

Management Measures: The selected plan includes the rehabilitation of the current horseshoe-shaped island system to form one interconnected island and the construction of a second major island. The existing islands upstream would be raised so that the top elevation of these islands would be approximately equivalent to a 10-year flood event. The top elevation of the proposed islands is, on the average, about 4.7 feet above the normal water surface in the project area. All openings between these islands would be closed through the placement of fill. Upon completion, the entire island system would essentially form a 9,500-foot-long barrier along the east side of the project area.

The key island design consideration from the standpoint of erosion control was selection of the island cross-section and those areas which would require the additional protection afforded by riprap. The top width of the islands was selected based on the topography of the existing islands, coupled with island stability and economic considerations. The minimum width will be 50 feet, with expansions up to 100 feet in a few areas. From the top of the proposed islands, side slopes would be 1V on 3H. At an elevation approximately two (2) feet above normal pool, the side slopes would decrease dramatically to form a 20-foot wide berm which gradually slopes to about 1V to 20H.

Then, from a point one (1) foot above normal pool, the side slopes would again change to approximately 1V to 6H. The berm slopes were designed to combine ease of construction with what nature would most likely create over time.

About 225,000 cubic yards of material would be needed to construct the proposed project plan. Approximately 3,300 linear feet of the islands most susceptible to erosive action would be riprapped.

Riprap quantities are estimated to be 5,000 cubic yards. Riprap will only be required in selected reaches of the islands system. Placement was based on flow considerations and field investigations. The head of the horseshoe shaped island will be riprapped, as well as a limited reach along the slough entrance. With the exception of the head of the existing island, where riprap was placed, no berm would be required.

Topsoil required for this option would be 13,200 cubic yards. Topsoil is to be placed on the upper portions of all constructed islands. Vegetation would be used to stabilize the island. No new topsoil or seeding would be put on the berm since the height of the berm is within range of normal wave action. The only exception to this will be the lower half of the new 5,000-foot-long downstream island. Here, the berm facing the main channel will be planted to stimulate plant growth for added protection. The topsoil will be seeded with a seed mixture which will include the most desirable species for island stabilization and wildlife habitat. Some of the species most likely used will include switchgrass and sand dropseed.

Costs: The total cost of this project is estimated to be $1,213,400 Jun. ‘89 ($1,407,544) with an average annual operation and maintenance cost of $3,200 (3,712).

Outputs/Benefits: It is expected that these changes should preserve the 400 acres of backwater habitat currently protected by the existing horseshoe-shaped island system. The project should also yield an increase in protected shallow and deep-water habitat of 100 and 30 acres, respectively, with positive effects of an additional 355 acres.

POTTERS MARSH, CARROLL AND WHITESIDE COUNTIES, ILLINOIS
Rock Island District

Location: Potters Marsh is located within Pool 13 of the Upper Mississippi River from RMS 523.5 to 526.5 and encompasses 2,305 acres of floodplain wetlands, wooded areas, and open water.

Resource Problems: A permanent backwater slough was created between what is now an island on the Illinois mainland following the construction of Lock and Dam 13. Siltation in the slough has reached critical proportions, with aquatic vegetation dominating the slough and drastically reducing the fisheries habitat. Siltation also has degraded the waterfowl marsh habitat at this location.

Objectives: The following objectives were identified for this project area:

- Restore and create fisheries habitat
- Reduce sediment input
- Increase migratory bird feeding or resting areas
- Increase waterfowl brood habitat and fall feeding sites

Management Measures: Eleven (11) alternative plans, shown below, were considered to meet the stated objectives. Evaluation of the project alternative plans was accomplished through the application of habitat value assessment methodologies. The Wildlife Habitat Appraisal Guide (WHAG), a habitat assessment methodology designed by the Missouri Department of Conservation, in cooperation with the U.S. Natural Resources Conservation Service (formerly the Soil Conservation Service), was used in the analysis of wetland and terrestrial feature basis. The alternative plans were evaluated on an individual and combined feature basis. Alternative plans 5, 6, 8, and 9 (highlighted below) were recommended and all met project objectives and were cost effective.

1) No Federal Action
2) Construct closure dike with water control structure
3) Redesign existing causeway
4) Construct barrier island
5) Dredge sediment trap - segment 1 and deep hole below causeway
6) Hydraulically dredge backwater channels - segments 2 and 3
7) Hydraulically dredge backwater channel - segment 4
8) Create pothole
9) Develop managed marshland
10) Develop grassland
11) Construct moist soil unit

Sediment Trap Creation. Immediately below the existing causeway, a deep-hole sediment trap will be mechanically excavated or hydraulically dredged. The hole will be 200 feet wide by 60 feet

long by 10 feet deep with 2V on 1H side slopes. Excavation/dredging depth will be 8.5 feet of material, totaling approximately 4,700 cubic yards. For the Segment 1 hydraulic dredging, the dredged bottom width will be 50 feet with a 2V on 1H side slopes for the 2,100 linear feet of alignment. Dredging depth will be a 10-foot cut to ensure a minimum depth of six (6) feet throughout the project life. The dredged material will be a total of 44,300 cubic yards.

Hydraulic Dredging. General dredging alignments for Segments 2 and 3 bottom width will be 50 feet with 2V on 1H side slopes. Dredging will be eight (8) feet to ensure a minimum depth of six (6) feet throughout the project life. Segment 2 will be 10,900 linear feet of dredging alignment and one (1) deep hole. Segment 3 will be 9,800 lineal feet of dredging alignment and one (1) deep hole. Each deep hole will be 500 feet by 200 feet with a 12-foot dredging depth and 2V on 1H side slopes. Dredged material in Segment 2 will total 205,350 cubic yards. Dredged material in Segment 3 will total 188,650 cubic yards.

Create Potholes. Sixteen potholes of various shapes will be mechanically excavated to about four (4) feet in the central part of the island. Excavated material will be placed around the outside perimeter of the pothole. An additional seven (7) 300- by 50-foot potholes will be blasted by explosives in the riverside embayment area near the central part of the island because excavation with conventional equipment would be difficult. A confined placement site (CPS) with approximately 35.5 interior acres and a 14-foot high dike will be required. A minimum of 3V on 1H side slopes is required with a 10-foot wide crest. A total surface area for the CPS is 50 acres.

Managed Marshland on CPS. After settlement of the dredged material, an approximate 32.5-acre managed marshland will be constructed on the CPS surface. This will involve installing a shallow well for water supply. Approximately 500 gpm of groundwater could be pumped (5 HP submersible pump) from the sand aquifer with approximately 20 feet of drawdown. In approximately 20 days, 500 gpm would inundate the 32.5 CPS acres with 1.5 feet of water. Only 1.0 foot of water would be necessary, but when considering infiltration, evaporation, and precipitation, it is necessary to inundate the CPS with 1.5 feet of water to ensure the 1.0-foot depth. For dewatering purposes, a 4.0-foot stoplog structure will be constructed. The managed marshland can be dewatered in three (3) to five (5) days. If dredged material continues to settle, additional stoplogs can be removed.

A grassland area will be constructed on the remaining CPS surface. The area will be seeded with selected grasses. This area will help compensate for any lost vegetation due to the CPS construction and will further enhance the habitat values for the site.

Costs: The total cost for this project is $3,957,000 Nov. '91 P.L. ($4,392,270) with an average annual cost of $6,100 ($6,771) for operation and maintenance.

Outputs/Benefits: Development of the selected plan will provide approximately 32 acres of manageable aquatic and wetland habitat and 38 acre-feet of off-channel, deep-water aquatic habitat.

SPRING LAKE, CARROLL COUNTY, ILLINOIS
Rock Island District

Location: Spring Lake, a 3,300-acre lake and backwater complex delimited by the natural river bank and a perimeter levee, is located on the Illinois side of the Upper Mississippi River, approximately two (2) miles south of Savanna, Illinois. It is divided into an upper and lower lake by a cross dike.

Resource Problems: Spring Lake was historically a highly productive and heavily used feeding and resting area for migratory waterfowl. However, due to breaching of the perimeter levee, deposition of sediments into Spring Lake, primarily during flood events, has caused a gradual decline in the quality and availability of aquatic habitat in Spring Lake. The shallow water conditions and low flows in the Lower Lake are negatively impacting dissolved oxygen levels.

Objectives: The following objectives have been identified for this project area:

- Improve water quality for fish
- Maintain backwater lake
- Provide reliable wetland vegetation/food source in the Upper Lake for migratory birds
- Provide reliable food source in Lower Lake for migratory birds and other wetland species

Management Measures: Three (3) alternative plans consisting of combinations of rehabilitation and enhancement features were considered.

1) No Federal action
2) Levee restoration/Upper Lake water control/inlet structure
3) Levee restoration/Upper Lake water control/inlet structure/Hemi-Marsh

Evaluation of the different alternative plans was accomplished through the application of habitat value assessment methodologies. The Wildlife Habitat Appraisal Guide (WHAG), a habitat assessment methodology designed by the Missouri Department of Conservation in cooperation with U.S. Natural Resources Conservation Service (formerly the Soil Conservation Service), was used in the analysis of wetland and terrestrial habitats. The aquatic version of the WHAG, referred to as MOFISH, was used to evaluate present and future conditions and changes in aquatic resources as a result of proposed alternative plans. The alternative plans were evaluated on an individual and combined feature basis. As a result of the analysis, Alternative Plan Three was recommended.

The recommended alternative plan consists of:

- Establishing three (3) independent water-controlled cells in the Upper Lake
- Constructing a gated inlet structure and excavated channels in the Lower Lake

- Constructing a 100-acre water-controlled hemi-marsh in the lower lake
- Restoring 7.1 miles of perimeter levee

A more detailed description of the selected alternative is described in the following paragraphs.

Perimeter Levee Restoration. It is proposed to restore the perimeter levee to a 50-year design elevation and to stabilize the sideslopes. The levee top (crown) width will be 12 feet and be offset to the lake side in order to reduce the amount of riverward tree clearing. The 12-foot top width is required for adequate levee stability. The length of the levee will be 2.6 miles. The Mississippi River sideslopes will have at least 1V on 3H and the lake side will have 1V on 4H sideslopes. The embankment borrow will be excavated adjacent soil. The borrow ditch will be 35 feet across at the bottom and about four (4) feet deep. A 20-foot wide nondisturbed zone will separate the borrow edge from the levee toe. Embankment volume of 41,000 cubic yards will be used. The tops and sideslopes will be seeded with the following seed mixture:

- Rice cutgrass (*Lleersia oryzoides*) - 6 lbs./ac.
- Big bluestem (*Andropogen gerardii*) - 6 lbs./ac.
- Little bluestem (*Andropogon scoparius*) - 4 lbs./ac.
- Indian grass (*Sorghastrum*) - 4 lbs./ac.
- Side oats gramma (*Bouteloua curtipendula*) - 4 lbs./ac.
- Prairie cord grass (*Spartina pectinata*) - 6 lbs./ac.
- Perennial ryegrass - 20 lbs./ac.

Upper Lake Management Plan. This feature consists of a 560-acre area bounded and divided by levees that form controlled ponding units. Because depths of approximately 1.5 feet were needed, a three (3)-celled unit was designed to take advantage of the existing topography. Water will be pumped into or out of the Upper Lake feeder channel from a new pump station (concrete gated structure with two (2) 7,000-gallon-per-minute pumps) located on the cross dike. This design provides capability to dewater Upper Lake and pump from Lower Lake into the Upper Lake and connect the Upper and Lower Lakes by gravity flow. The feeder channel can be used to fill or dewater any of the cells. The purpose of the stoplog structures (three (3) concrete structures each with five (5)-foot openings) is to allow flexible and independent operation of each cell. The following paragraphs are descriptions of components of the Upper Lake Management Plan.

- Cross Dike Raise - Raising and strengthening the cross dike by excavating adjacent soil for placement as levee embankments are proposed. The levee crown will be offset to the Upper Lake side in order to take advantage of the existing riprap on the Lower Lake sideslope. The levee crown will be raised to the 5-year flood elevation. The proposed cross dike will have a 12-foot crown width and 1V on 4H sideslopes. The completed embankment will have six (6)-inch gravel crown and the Upper Lake sideslope will be seeded. The length of this dike

will be 1.4 miles using embankment volume of 6,000 cubic yards and 1,700 tons of crushed stone.

- Modify Existing Overflow Structure - The proposed project includes raising the existing overflow structure. Another 200-foot overflow structure is proposed. The overflow sections were designed for those areas where overtopping will first occur during flood events greater than the 2-year frequency. Once overtopping of the overflow sections occurs, the Upper Lake cells will fill prior to overtopping of the cross dike. Riprap (1,000 tons) will be provided for the Upper Lake slopes. Tree buffers and existing riprap will provide adequate protection of the Lower Lake slope.

- New Pump Station - The pump station has been sized to evacuate all three (3) cells of the Upper Lake in approximately 15 days. The pump station will be furnished with two (2) pumps in order to dewater Upper Lake and to pump water from the Lower Lake into the Upper Lake. The sizes of these pumps will be 7,000 gpm. The station will be furnished with a trash rack on both sides due to flow reversals. The inverts of the station have been set consistent with refuge ditching and adjacent natural ground elevations. A sedimentation zone has been provided on the Lower Lake side with an overflow weir protecting the entrance to the station to minimize sediment entering the pump station during drawdown periods. The station will also contain a 3-foot by 3-foot sluice gate and a 24-inch discharge pipe to allow passage of gravity flows. Two hundred and eight (208) tons of riprap will be used.

- Interior Levees - Embankment slopes are 1V on 4H which will facilitate levee maintenance and reduce burrowing animal problems. The length of the interior levees will be 7,200 feet with a top width of 10 feet typically and 12 feet when they are being used as access to the stoplog structures and other operational requirements. The average height of the levees is approximately five (5) feet. The levees will be excavated from an adjacent borrow source. The borrow sources have been developed to facilitate drainage for operational requirements. Total embankment volume of 7,600 cubic yards and 1,050 tons of crushed stone is included in this feature.

- Stoplog Structures - These structures consist of a concrete sill with concrete dividing walls and abutments that incorporate stoplog recesses. The stoplog recesses will be used for water control of the cells. A heavy-duty grating across the structure will provide for vehicular access. The hydraulic opening of these structures has been determined based on hydrologic simulation of flood events and in conjunction with the overflow structures on the cross dike. Weir length per structure is five (5) feet.

Inlet Structure. The water control structure was sized by determining the flow necessary to provide the amount of fresh water needed for fish habitat. The volume of water necessary to provide 5mg/l of dissolved oxygen was based on the area and depth of the lake and an oxygen balancing analysis. It was determined that 175 cfs of flow is necessary. Based on typical river elevations during low-flow winter conditions, two (2) 5-foot by 5-foot slide gated box culverts will be adequate to provide the necessary flow. Also included are two (2) trash racks and 300 tons of riprap.

Excavated Channels. The excavated channels were designed to distribute the flow throughout the lake. The greater the area that the flow reaches, the more benefit to the fisheries aspect of the project. The affected area was quantified by developing an RMA-2 two-dimensional flow computer model. This model predicts the magnitude and direction of flow velocities. The length of these channels are 13,100 feet. The depth of dredge cut was based on maintaining a 6-foot depth over the project life. A typical dredge section will have a 35-foot bottom width and 1V on 2H sideslopes with the mechanically excavated material being sidecast. The resulting sidecast islands will function as nesting islands. Total excavated volume is 126,650 cubic yards.

Hemi-Marsh Development. This feature consists of developing an approximate 100-acre hemi-marsh located on the southeastern fringe of the refuge. It is proposed that a low-level perimeter levee, a stoplog structure, and a well station be constructed, as described below.

- Low-Level Perimeter Levee - The levee top elevation (2-year flood event) was based on the capability of ponding two (2) feet of water in the hemi-marsh. The levee top width will be eight (8) feet and the sideslopes will be 1V on 4H with a total length of 6,100 feet. The embankment borrow will be excavated (10,000 cubic yards) adjacent soil from the lake sides of the hemi-marsh. The sideslopes will be seeded. A 10-foot wide crushed stone (1,800 tons) access road will be provided at each end of the embankment for access to the well station and stoplog structure.

- Stoplog Structure for Hemi-Marsh - The structure will have a five (5)-foot opening. The purpose of the structure is to enable gravity drainage and provide a means of varying the water elevation within the hemi-marsh. The structure consists of a concrete sill with concrete abutments that incorporate stoplog recesses. The stoplog recesses would be used for water control. A heavy-duty grating would be provided across the structure to allow vehicular access.

- Water Supply - The well station will involve installing a shallow well (125 feet) for water supply. It has been estimated that 1,000 gpm of groundwater could be pumped from the sand aquifer with about 9.5 feet of drawdown. The well will be used to raise the water level in the hemi-marsh during low river periods. A 1,000-gpm pump will provide an additional one (1) foot of water on the entire 100 acres when considering evaporation, infiltration, and rainfall. A five (5)-horsepower submergible pump will be required for this well.

Costs: This alternative will have a fully-funded estimate of $5,849,000 Oct. '92 P.L. ($6,375,410). Project operation and maintenance is estimated at an average annual cost of $31,094 ($33,892).

Outputs/Benefits: For this selected alternative, habitat improvements, based on the percentage increase of habitat units, for each of the following enhancement features are estimated to be:

- Upper Lake - 152 percent
- Lower Lake - 407 percent
- Hemi-Marsh - 99 percent

STUMP LAKE, JERSEY COUNTY, ILLINOIS - ILLINOIS RIVER
St. Louis District

Location: The Stump Lake complex extends from Illinois River miles 7.2 to 12.7 along the left (east) bank of the Illinois River. This area includes 2,958 acres of backwater lakes, 1,221 acres of open wetlands and sloughs, 252 acres of cropland, and 1,485 acres of forest.

Resource Problems: The primary problems in this area are sedimentation and water level fluctuations. The sedimentation rate is averaging 0.5 inch per year. Silt and a lack of stable water levels are detrimental to aquatic and moist soil plant production. Moist soil techniques require 50 to 90 days for development and maturity of food plants. Inefficient and aging water levels control structures and a lack of protection from Illinois River waters at bank full and above stages allow for successful wildlife food production only 50 percent of the time on average.

Objectives: The objectives for this project area are:

- Decrease sedimentation
- Improve water level control
- Improve seasonal slackwater fish habitat in two (2) of the lakes
- Improve fish spawning from Illinois River to two (2) of the lakes
- Reduce sedimentation in two (2) of the lakes
- Increase photic zone in project waters

Management Measures: The project currently under construction includes the following eight (8) features:

1) Low Profile Exterior Sediment Deflection Levee

- Approximately 5.5 miles of levee, paralleling the Illinois River shoreline and the perimeter of the project area, which will reduce siltation, that occurs from frequent floods, and improve wetland unit water control

- A 10-foot crown width and 1V on 3H side slopes

- Clearing, borrow, and construction limits will not exceed 180 feet in width and will average about 120 feet

- Borrow areas (34 acres) will be managed as additional open wetland habitat

- Vegetation removal will be restricted as much as possible

- Special attention will be given to minimizing any removal or damage to den, nest, perch, and mast trees

2) Low-level Interior Levees

- Seven (7) levees located in specific "low spots" around the perimeters of the four (4) main units to allow effective water level management capabilities and to compensate for existing sedimentation

- Borrow areas (14 acres) will be managed as additional open wetland habitats

3) Sluice-gated corrugated metal pipe (CMP) structures; stoplog drainage structures; and sluice-gated concrete "Fish Passage" structures

- Six (6) sluice-gated CMP structures, two (2) stoplog structures, and four (4) fish passage structures to perform and control water and dewatering of the four (4) wetland management units

- Culverts will be sized to handle capacity for water and/or dewatering wetland units within a two (2) week period (dependent on river level conditions)

- Various water control structures: two (2) - 36-inch CMP with sliding gate culverts (use existing structures), one (1) - 42-inch CMP with sluice gates and gatewells (replacing gated culvert), eight (8)-foot wide concrete stoplog structure to allow boat passage and water control (new) (replacing one (1) - 36-inch gated culvert, two (2) - 42-inch CMP with sluice gates and gatewells (replacing two (2) - 36-inch gated culverts, eight (8)-foot wide concrete stoplog structure and open channel to allow water control and boat passage (new), three (3) - 42-inch CMP with sluice gates and gatewells (replacing two (2) - 24-inch and one (1) - 36-inch gated culverts).

4) Concrete Fish Passage and Water Control Structures

- Four (4) chamber open concrete fish passage and water control structures, with four (4) - 42-inch sluice gates

- Each chamber is five (5) feet wide and nine (9) feet high

5) Remove Stoplog Structure

- From across one of the lakes

6) Install Electronic River Gauge Station

- At one of the water control structures to improve water management decision-making for the entire wetland complex

7) Dredging

- Approximately 160,00 cubic yards to improve water delivery and facilitate fish movement, spawning, and rearing
- Dredged sediments will be deposited into a wetland compartment
- Sediment deposition will elevate the bottom but will still allow the wetland to be managed as a moist soil unit. However, a 5,000-gpm portable pump will be needed to supplement the gravity flow structure into the wetland because of the lack of head differential.

8) Reversible Pumping Station

- A flow rate of 90 cfs on the Illinois River will be used to allow flooding or draining of the wetland compartments
- Two (2) permanently located pumps operated by one portable drive unit will be required
- The outlets/inlets for the wetland complex will be located at the most efficient location to the Illinois River from the wetland complex

Costs: The total project cost is estimated to be $4,059,300 Oct. '90 P.L. ($4,587,009) with an estimated average annual operation, maintenance, and rehabilitation cost of $33,700 ($38,081). Preconstruction, construction, and post-construction monitoring will be implemented at an annual cost of approximately $7,000 ($7,910).

Outputs/Benefits: The selected alternative will provide a net increase of 753 AAHUs at a project cost of $445 per AAHU and also a 79 percent reduction in sediment-carrying waters into the project. The project will provide a three (3) to four (4)-year flood protection and is designed to provide habitat benefits for approximately 50 years.

SWAN LAKE, CALHOUN COUNTY, ILLINOIS - ILLINOIS RIVER
St. Louis District

Location: Swan Lake is located on the west bank of the Illinois River between River miles 5 and 13. The immediate project area includes 2,900 acres of Swan Lake, 200 acres of Fuller Lake, approximately 950 acres of bottomland forest, and 500 acres of cropland surrounding these lakes (totaling 4,600 acres). Also included in the project area is the local watershed adjacent to Swan Lake's west shore.

Resource Problems: The major threats to the Swan Lake complex are: sedimentation, water level fluctuations, and wind-generated waves. The lake receives substantial sediment input, not only from floodwaters from the Illinois River, but from a 30 square mile watershed adjacent to the lake's west shore. It is estimated that two-thirds of the lake's sediment is from the river, and one-third is from the hillsides. The existing overall deposition rate in the lake is 0.5 inch per year, and is expected to average 0.33 inch per year over the next 50 years, resulting in a 30 percent reduction in lake surface area.

Sedimentation results in a direct loss of fish and waterfowl habitat acreage over time. It also results in decreased water depth, leaving fish susceptible to temperature extremes during the summer and winter periods and to the effects of lake freeze during the winter. Sediment also contributes to a soft lake bottom, not conducive to plant anchorage, and contributes to high turbidity levels when agitated by wind-generated waves. This increased turbidity results in reduced light penetration into the water column, causing reduced photosynthetic activity, and reduced plant production. Lost plant production results in food supply impacts to both waterfowl and fish. The project area is also affected by water level fluctuations in river stage. Water elevations can fluctuate by a number of feet above normal pool stage and for extended periods of time. These fluctuations can impact the growth of wetland plants, and the availability of these plants as a food source for waterfowl. An influx of cold flowing water from the river during the winter can place a severe physiological stress on the lake's fish populations.

Objectives: The stated objectives for this project are the following:

- Substantially reduce future sedimentation
- Maintain stable water levels during the growing season
- Provide the ability to solidify the lake bottom
- Provide wave control
- Form smaller independently managed lake units
- Provide areas of deep water
- Allow for free movement of fish between river and lake during fall and early winter
- Buffer impact of cold water and ice
- Provide alternate structures so as to assure fish passage

Management Measures: The selected plan features currently under construction are described in the paragraphs below.

1) Riverside Dike or Levee

- Three (3) segments totaling 46,700 feet

- The first segment will total 2,000 feet in length and will consist of an impervious core with an exterior protective stone covering with "B" stone on the riverside and "C" stone on the lakeside and on the top. Soil core and stone will be placed with a 1V on 4H side slopes. The crown width of the completed structure will be 10 feet and top of closure will be topped with 6-inch aggregate road course.

- The second segment will total 29,100 feet in length and will consist of clamshell excavated lake sediments from adjacent lake shore. After lake sediments are dried, material will be graded to 1V on 4H side slopes. The height of this segment will range from three (3) to six (6) feet. The lowermost 2,000 feet of this segment will serve as an overflow structure and is protected by "C" stone.

- The third segment will total 15,600 feet in length and will be constructed from borrow material. Side slopes will be 1V on 3H with a crown width of eight (8) feet. Levee height will vary from three (3) to six (6) feet and will be topped with aggregate road course. Willow plantings at toe of levee and at river bank will provide the levee with protection from river floods.

2) Interior Lake Closure

- Designed closure will subdivide the area into middle and lower lake compartments and will also serve as a wave barrier.

- Structure will include an impervious inner core with 1V on 3H side slopes, a crown width of 10 feet, and will be protected with an 18-inch- layer of "C" stone.

3) Water and Sediment Control Traps

- In the upland watershed an upland sediment control program was chosen over bottomland sediment traps because it was determined by an engineering analysis to be more effective and less costly by $2.3 M ($2.5M).

- Consist of 95 water and sediment control basins: 55 ponds and 40 terraces
- Impoundments will generally be less than five (5) acres with a 24-hour release rate

- Operation and maintenance costs and real estate costs are the responsibility of the local landowners

4) Island Groups

- Two island groups, 3,000 feet in length and oriented perpendicular to prevailing winds
- Each island group will be created from clamshell excavated material placed in two (2) staggered rows
- A 1V on 6H side slope for the islands, to protect them from waves, with a width ranging from 60 to 100 feet
- Willow plantings along the shoreline would further stabilize the island shoreline
- Spacing of islands would vary from 100 to 500 feet, and length varying from 200 to 500 feet
- No above water disposal of material to occur closer than 500 feet from the lake shores
- Islands would be vegetated to grass cover initially and subsequently managed, with some of the islands in herbaceous cover and some in forested cover

5) Boat Access

6) Lower Swan Lake Water Control Structures

- Located at the downstream end of the lower lake closure for regulating water levels and fish passage
- Consisting of a 20-foot wide segment of an open-topped concrete channel with four (4) spans of five (5)-foot wide stoplog bays
- Including a 10-foot wide segment of open-topped concrete channel with a 72-inch sliding gate lakeside and a 72-inch sluice gate riverside
- A chamber will house a single 20,000-gpm couch pump adapted for bi-directional pumping between river and lake
- The fish screens will be provided at the pump station

- The pump will be driven by a 87-hp portable diesel power plant, fueled from a 1,000-gallon portable fuel tank
- The top of the control unit will have a concrete roadway for vehicle passage and a concrete pad for parking powerplant and fuel tank
- The water levels will be monitored with staff gauges and automatic gauges located riverside and lakeside of the water control unit

7) Middle Swan Lake Water Control Structures

- Identical in design as in Lower Lake
- The 300-foot-wide and 300-foot-long ditch will be excavated for water conveyance
- The staff gauges will be placed riverside and lakeside of the control unit with an automatic gauge placed lakeside
- A single 48-inch CMP will be through the new interior lake closure
- The structure will allow for additional water input to lower compartment from middle compartment prior to pump activation

8) Upper Swan Lake/Fuller Lake Water Control Structures

- A 48-inch gated CMP will drain management unit into the Illinois River
- Pump (20,000-gpm reversible couch pump) driven by 87-hp portable diesel power plant, fueled from 1,000-gallon tank
- A 10-ft-wide, 800-ft-long ditch will serve to convey water to and from control structure
- The fish screen will be provided at pump station
- The staff gauge will be placed riverside of the water control unit

Costs: The total estimated cost for this project is $7,854,000 Dec. ‘ 92 P.L. ($8,482,320) and the cost of operation and maintenance would be $41,000 ($44,280) annually.

Outputs/Benefits: The islands will provide an additional 25 percent wave control. Some of the islands will be maintained in grass cover to provide optimal mallard duck nesting habitat, while

others will be allowed to undergo natural secession to a forested state. Lake habitat benefits from wave control (which increases plant production) will yield 47 AAHUs for waterfowl and 71 AAHUs for fish.

Dredging will result in a drainage system needed for bottom solidification. The resulting deep water will also serve as an improved habitat for diving ducks and fish. Other features for this project include borrow areas, parking lots, and roads.

Habitat enhancement from the project would be anticipated to result in a new gain of 1,021 average annual habitat units (AAHUs) for waterfowl and 669 AAHUs for slackwater fish. The project is designed to provide habitat benefits for approximately 50 years. The hillside sediment control (partnership program) will reduce hillside sediment input to the lake by 30 percent, and overall lake sedimentation by 17 percent. This measure, combined with the dike/levee embankment measure, will show a potential 60 percent reduction in lake sedimentation. The hillside sediment control measure will provide a net gain of 105 AAHUs for waterfowl and 67 AAHUs for fish. Other benefits would include reduced farm soil loss, dollars to local economy, upland game habitat improvement, upland marsh habitat creation, and an important interagency cooperative precedent.

The dike/levee embankments which includes water control structures will reduce river sediment input by 85 percent and overall lake sedimentation by 43 percent. Flood events during growing season will be reduced from the present one (1) in two (2) years to one (1) in eight (8) years. Cold water intrusion will be reduced from annual intrusion to one (1) in two (2) years. This measure will provide an increase of 634 AAHUs for waterfowl and 320 AAHUs for fish. This feature will permit periodic bottom solidification, improve plant anchorage conditions, and lower turbidity levels. Fish movement will be allowed via open channel water control structures.

The interior lake closure management measure will divide the lake into smaller independently manageable units, increasing habitat diversity. This measure will also serve in reducing wave action. The gated CMP will allow additional water into the lower lake prior to pumping. This measure will provide an increase of 235 AAHUs for waterfowl and 164 AAHUs for fish.

CHAPTER IV - COASTAL WETLANDS PLANNING, PROTECTION AND RESTORATION ACT

The State of Louisiana contains 40 percent of the Nation's coastal wetlands, but is experiencing 80 percent of the Nation's coastal wetland loss. The widespread and complex nature of the coastal wetland loss problem, coupled with the diversity of agencies involved and numerous alternatives proposed, has led many in Federal, state, and local government, as well as the general public, to the conclusion that a comprehensive approach is needed. The Coastal Wetlands Planning, Protection and Restoration Act (PL 101-646) was signed into law by then President George Bush on November 29, 1990, to address the need for a comprehensive approach to this significant environmental problem.

Section 303 (a) of the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) directs the Secretary of the Army to convene the Louisiana Coastal Wetlands Conservation and Restoration Task Force to:

> . . . initiate a process to identify and prepare a list of coastal wetlands restoration projects in Louisiana to provide for the long-term conservation of such wetlands and dependent fish and wildlife populations in order of priority, based upon the cost-effectiveness of such projects in creating, restoring, protecting, or enhancing coastal wetlands, taking into account the quality of such coastal wetlands, with due allowance for small-scale projects necessary to demonstrate the use of new techniques or materials for coastal wetlands restoration.

Section 303(a)(1) of the CWPPRA directs the Secretary of the Army to convene the Louisiana Coastal Wetlands Conservation and Restoration Task Force, to consist of the following members:

- the Secretary of the Army (Chairman)
- the Administrator, Environmental Protection Agency
- the Governor, State of Louisiana
- the Secretary of the Interior
- the Secretary of Agriculture
- the Secretary of Commerce.

To assist in putting the CWPPRA into action, the Task Force established the Technical Committee and the Planning and Evaluation Subcommittee. Each of these bodies contains the same representation as the Task Force -- one member from each of the five (5) Federal agencies and one (1) from the State. The Planning and Evaluation Subcommittee is responsible for the actual planning of projects and preparation of this restoration plan, as well as the other details involved in the CWPPRA process (such as development of schedules and budgets); the subcommittee makes

recommendations to the Technical Committee and lays the groundwork for all decisions which will ultimately be made by the Task Force. The Technical Committee operates at an intermediate level, between the planning details considered by the subcommittee and the policy matters addressed by the Task Force, and often formalizes procedures and assists in formulating policy for the Task Force.

The Planning and Evaluation Subcommittee established several working groups to evaluate projects for Priority Project Lists and the restoration plan. The Environmental Work Group was charged with estimating benefits (in terms of wetlands created, protected, enhanced, or restored) associated with various projects. The Engineering Work Group reviews project cost estimates for consistency. The Economic Work Group performs the economic analysis which permitted comparison of projects on the basis of their cost effectiveness. The Monitoring Work Group establishes a standard procedure for monitoring of CWPPRA projects and develops a monitoring cost estimating procedure based on project type.

The Planning and Evaluation Subcommittee also established an interdisciplinary basin team for each of the nine (9) hydrologic basins in the coastal area. The nucleus of each team consists of representatives of the five (5) federal Task Force agencies and the State; these six (6) members makes the final decisions on team recommendations. However, team meetings frequently involves additional agency representatives, scientific advisors, and local interests. The basin teams serve as the first level of screening for proposed Priority Project List projects and helps shape the comprehensive restoration plans for the basins.

The nine (9) hydrologic basins in the coastal area are as follows:

1) Pontchartrain Basin
2) Breton Sound Basin
3) Mississippi River Delta Basin
4) Barataria Basin
5) Terrebone Basin
6) Atchafalaya Basin
7) Teche/Vermilion Basin
8) Mermentau Basin
9) Calcasieu/Sabine Basin

Each of these basins contain several project areas and each project area has different Federal sponsors. For the purpose of this report, a sample of projects will be briefly discussed. The sample discussed was obtained from the 2nd and 3rd Priority Project List Reports (see References). Over a period of time, the Priority Project Lists have gone through some changes. Some of the projects may have been deleted, deauthorized, or lead sponsors may have changed. But for the purposes of this report, the main objective is the compilation of various management measures.

Atchafalaya Bay Booster Pump Marsh Creation
New Orleans District

Location: The project is located in Atchafalaya Bay in the lower southeast corner of St. Mary Parish. It is a shallow open water area located to the east of the Chene, Boeuf, and Black navigation channel in the Lower Atchafalaya River delta. The project area is just south of the eastern half of the Lower Atchafalaya River delta.

Resource Problems: Annually, the Corps dredges an average of 2,000,000 cubic yards of sediment from the Chene, Boeuf, and Black navigation channel and disposes of the material in designated disposal areas adjacent to the channel. This material could be beneficially used in other areas of the Lower Atchafalaya River delta to create new delta lobes, create the foundation for losses from natural processes such as waves, currents, and passage of cold fronts. This project addresses a strategy for managing the growth of the Lower Atchafalaya River delta to decrease the output of sediments from the Atchafalaya Bay.

Management Measure: The planned work consists of dredging material from the Chene, Boeuf, and Black navigation channel by hydraulic cutterhead pipeline dredge. The dredge material will be transported through dredge pipe, using booster pumps, to an area just south of a delta lobe between God's Pass and South Pass. This material will be disposed unconfined in shallow open water in areas where vegetation can occur.

Costs: The approximate cost for this project is $977,000 Oct. '93 P.L. ($1,035,620).

Outputs/Benefits: It is estimated that, over a 20 year project life, this project will create or restore 80 acres of wetlands and enhance 10 acres of wetlands. An additional 20 acres of aquatic vegetation will also benefit for a total of 110 acres.

Black Bayou Culverts Hydrologic Restoration
New Orleans District

Location: The project is located on Black Bayou in Calcasieu Parish, near the Calcasieu Lock on the Gulf Intercoastal Waterway. Black Bayou is closed by a dam where Highway 384 crosses the bayou. The project area extends east into Cameron Parish as far as Grand Lake.

Resource Problems: Prolonged high water levels, in the Grand and White Lakes area, compound the problem of wind-induced wave erosion and cause stress to marsh grasses.

Management Measures: The proposed project consists of five (5) 10-foot by 10-foot gated box culverts under Highway 384 to facilitate drainage from the basin. The outfall from the culverts will provide fresh water, nutrients, and some sediments to brackish marshes to the west.

Cost: The cost for this project is approximately $9,639,000 Oct. '93 P.L. ($10,217,340).

Outputs/Benefits: The project will provide 650 average annual habitat units (AAHU's) and the project's cost is estimated at $1,363/AAHU ($1,445/AAHU).

Channel Armor Gap Crevasse
New Orleans District

Location: The project is located in the Mississippi River Bird's Foot Delta in Plaquemines Parish on the left descending bank of the river at approximate River mile 4.9, six (6) miles south of the city of Venice. The project outfall area is located adjacent to the river channel and Main Pass, within the boundary of the Delta National Wildlife Refuge and consists of 2,100 acres of fresh/intermediate marsh.

Resource Problem: The area, which is adjacent to the Mississippi River, no longer receives marsh-nourishing sediment from the river due to the enhancement of the bank line. Shallow gaps have been built in the stone armor of the river bank to allow overflow during periods of high river flow. Due to infrequent and inadequate volume of flow, these gaps are not presently producing splays of emergent delta. The existing crevasse can be enlarged to allow additional flow and sediments to enter and deposit in shallow open water areas to create new emergent marsh.

Objective: The objective for this project is to utilize available sediment to create emergent marsh in areas which are currently shallow open water bottoms.

Management Measure: The objective can be met by enhancing existing structures and channels. The result will be the conversion of an area of 60 percent open water to an area of approximately 90 percent emergent wetland.

The construction of a crevasse utilizing an existing gap would involve deepening the cross-section and extending an outflow channel into the open water beyond the bank. By deepening the invert of the existing 200 foot wide gap in the Mississippi River channel armor, freshwater and sediment will be introduced into a 1,500-acre area at a rate of 2,500 cubic feet per second. The existing invert will be lowered to -4.0 feet NGVD. In addition, an existing earthen channel leading from the armor gap to the open water area beyond the bank will be enlarged. This channel will have an invert depth of -3.5 feet NGVD and a bottom width of 200 feet allowing an average flow of 2,500 cubic feet per second to enter the outfall area. Approximately 125,000 cubic yards of material will be excavated from the outfall channel and cast adjacent to the channel in a manner conducive to marsh nourishment. The material will be placed to an elevation not to exceed +3.0 feet NGVD.

Costs: The cost of this project is approximately $665,000 Oct. '93 P.L. ($704,900). Monitoring costs for this type of project is estimated at $8,625 ($9,142) per year under the CWPPRA monitoring criteria.

Outputs/Benefits: Over the 20-year project life, 1,000 acres of emergent marsh will be created. A net gain of 936 acres is expected. The project will create 37 acres of shallow open water bottom suitable for the growth of aquatic vegetation as well as enhancing 51 acres of existing marsh.

Project implementation will reduce the loss rate in the project area by approximately 50 percent, thus the project will prevent the loss of 163 acres of fresh/intermediate marsh. The project will provide 234 average annual habitat units (AAHU's) and the project's cost is $286/AAHU ($303/AAHU).

Eastern Isle Dernieres Barrier Island Restoration
New Orleans District

Location: The project involves restoration of Eastern Isle Dernieres in Terrebonne Parish and includes marsh creation. The project is the eastern island of the Isles Dernieres chain and just south of Lake Pelto.

Resource Problem: The barrier islands in the Timbalier Subbasin offer significant protection to mainland marshes; however, the Isles Derniers chain is expected to disappear within the next decade if no restoration efforts are undertaken. Due to natural and human forces, the island has one of the most rapidly deteriorating shorelines in the world. The entire chain of islands may be submerged by the year 2020, with Eastern Isle Dernieres predicted to be submerged much earlier.

The rapid erosion, breaching, and disappearance of the island will expose the wetlands and estuaries to greater wave and current action. Bay areas will be open to direct wave attack from the Gulf of Mexico. The result is accelerated conversion of estuarine areas to a less productive open Gulf of Mexico habitat.

Without the protection of the barrier islands, the estuaries in the lower deltaic plain are susceptible to a dramatic increase in erosion rates and, consequently, further land loss.

Objectives: The objectives of this project are to restore the coastal dunes and wetlands of the Eastern Isle Dernieres, enhance the physical integrity of the islands, and protect the lower Terrebonne estuary and associated vegetated wetlands against direct exposure to the Gulf of Mexico.

Specific objectives are to increase the height and width of the barrier islands and close breaches, using sediment and vegetation. Overwash will be prevented lessening loss of back marsh. Habitat will be provided for fish and wildlife, including migratory birds.

Management Measures: The proposed two (2)-mile marsh restoration and creation is based on experience gained in a successful pilot project implemented by Terrebonne Parish in 1985. Overwash sediments will be used to build up dunes. Dune heights will be approximately eight (8) feet, and the dune will be seeded. Emergent sands will be used to close breaches and build retaining structure behind and over which dredged material will be pumped.

Sediment will be suction dredged from bay areas behind the island and used to hydraulically fill the area between dunes and earthen retaining structures. An elevated platform, up to three (3) feet NGVD, will be planted with species appropriate to brackish marsh.

Costs: The total first cost for this project is approximately $5,414,000 Oct. '93 P.L. ($5,738,840).

Outputs/Benefits: The project will create wetlands and provide wildlife and fisheries habitat. The project will be additive to the existing restoration site at the eastern most end and will extend two (2) miles to the west. At least 105 acres of saline marsh will be directly created by this project.

Construction of a barrier island system, which is continuous, high and wide, will provide greater protection than the existing system to back-barrier bays, estuaries and marshes. The protection comes from a combination of island features, including: reduction of overwash erosion and island breaching; reduction of fetch for local wind induced waves; greater energy dissipation of storm surges; fewer tidal inlets; and less saline intrusion.

Life expectancy of the islands will be extended possibly to some 30-40 years into the future.

Gulf Intercoastal Waterway (GIWW)/Freshwater Bayou Bank Stabilization
New Orleans District

Location: This project is located in the Lakes Sub-basin two (2) miles southwest of Intracoastal City on the Freshwater Bayou Canal. It is also located immediately south of its joining with the GIWW in Vermilion Parish, Louisiana.

Resource Problems: Freshwater Bayou was enlarged to a width of 300 feet to accommodate additional commercial boat traffic. As a consequence, increased tidal exchange, wave action, and wave wash from boat traffic have greatly increased shoreline erosion along Freshwater Bayou Canal. It has expanded in width to almost 600 feet. The existing disposal banks along sections of the channel have been eroded away, allowing tidal scouring and breakup of the adjacent marshes to occur. Without shoreline protection, the channel will continue to widen, consuming additional sections of disposal banks and adjacent marsh in the process.

Objectives: Shoreline stabilization will halt erosion and preserve habitat for wetland dependent fish and wildlife. This project is compatible with the basin strategy of maintaining the geologic framework of the basin by controlling erosion of shorelines and navigation channels.

Management Measure: The project consists of 8,000 linear feet of riprap bank stabilization along the west bank of the Freshwater Bayou Canal, beginning at its confluence with the GIWW.

Cost: This project will cost approximately $700,000 Oct. ‘93 P.L. ($742,000).

Outputs/Benefits: This project will protect 60 acres of fresh marsh.

Lake Athanasio Spit Marsh Creation
New Orleans District

Location: This 6,360 acre project area is located in the saline marshes of southern St. Bernard Parish, on the eastern shore of Lake Athanasio.

Resource Problem: The shore of the spit, which makes up the eastern shore of Lake Athanasio, is undergoing rapid erosion. The marsh loss rate on the spit and around Lake Athanasio was approximately 50 percent per year from 1974 to 1983. From then until the present, the loss rate has increased to approximately 75 percent per year. The spit protects the interior shorelines of the lake from wind and wave erosion. Once this spit erodes, the lake will erode more rapidly.

Objective: The objective of this project is to preserve the spit by utilizing dredged material from maintenance of the Mississippi River Gulf Outlet (MRGO).

Management Measure: Dredged material from MRGO will be pumped two (2) miles to the spit and used to fill four (4) ponds/bays along the western edge of the spit to improve its integrity. Approximately 380,000 cubic yards will be needed to fill these 2-foot deep ponds to marsh level.

Costs: This project is estimated to cost $866,000 Oct. '93 P.L. ($917,960). The estimated cost per benefitted acre will be $579 ($614).

Outputs/Benefits: It is estimated that about 100 acres of marsh will be created in the ponds. Preserving the spit was assumed to reduce the loss rate from the present rate, of about 75 percent per year, to the earlier rate of about 50 percent per year. Over 20 years, this will preserve 108 acres of marsh. Submerged aquatic vegetation will be likely to grow over an additional 789 acres. The project should enhance 697 acres. Thus, the total benefitted acres will be 1,694.

Marsh Creation - Barataria Bay Waterway Maintenance Dredging
Jefferson Parish, Louisiana
New Orleans District

Location: This project is located in Jefferson Parish, Louisiana. The project consists of using sediments dredged for maintenance of the Barataria Bay Waterway between River mile 0.0 at Barataria Pass, and River mile 16.0, near Bayou St. Denis. It would consist of creating marshes at several individual sites along some 16 miles of the waterway.

Resource Problem: Marsh areas adjacent to the Barataria Bay Waterway have eroded rapidly due to boat wakes, salt water intrusion, and tidal scour. The reach of the Barataria Bay Waterway, which traverses the open waters of Barataria Bay, must be dredged for maintenance at about four (4)-year intervals. Currently, sediments dredged from the waterway are placed in designated disposal areas adjacent to the waterway. With project implementation, this material would be used beneficially to create new marsh and nourish existing marsh near the waterway.

Objective: The objective for this project is to create vegetated wetland using sediments dredged for normal maintenance of the Barataria Bay Waterway.

Management Measures: The project would involve using sediments dredged for maintenance of the Barataria Bay Waterway to create marsh in shallow water areas adjacent to the channel. Eighteen (18) marsh development areas, ranging in size from about 15 to about 133 acres, are proposed, between River mile 0.0 (at Barataria Pass) and River mile 16.0 of the waterway (near Bayou St. Denis).

The channel is dredged for maintenance at about four (4)-year intervals; consequently, over the 20-year life of the project, channel dredging would be performed about five (5) times. On average, approximately 1,740,000 cubic yards of dredged material are excavated and placed in disposal areas within the project reach during each dredging cycle. Hydraulic cutter-head dredges and bucket dredges are currently used to excavate the material. Bucket dredges place material in designated areas on both sides of the channel. The hydraulic cutter-head dredges place material in three (3) designated confined disposal areas on the east side of the channel.

With this proposal, hydraulic cutter-head dredges would be used, exclusively, for maintenance of the waterway. Dredged material from maintenance of the waterway would be placed in shallow water areas on both sides of the channel at an elevation conducive to marsh development. The marsh development areas would be confined to minimize damage to producing oyster beds located in Barataria Bay. Typical confinement would consist of three (3) to five (5)-foot high soil dikes.

Dredged sediments would be placed to an elevation of +4.0 feet NGVD (National Geodetic Vertical Datum of 1929.) After consolidation, a final design elevation of +2.0 feet NGVD would be

obtained. Approximately six (6) months of pumping time would be required for the dredged material placement. An additional 12 months would be required for consolidation of the dredged material to about elevation +2.0 feet NGVD. To create marsh, dredged material must be pumped greater distances than would be the case for normal maintenance of the waterway. Consequently, additional costs over present maintenance costs would be incurred.

Cost: Engineering and design, supervision and administration of engineering design will cost approximately $5,000 Oct. '91 ($5,600); project construction is approximately $184,000 ($206,080); supervision and inspection of construction contract(s) is approximately $19,000 ($21,280); and operation and maintenance (average annual costs over normal maintenance, etc. and duration period of 20 years) is approximately $44,000 ($49,280).

Benefits: Project implementation would create approximately 445 acres of saline marsh over the 20-year life of the proposed project.

Marsh Creation - Bayou La Branche Wetlands
St. Charles Parish, Louisiana
New Orleans District

Location: This project is located in the Bayou La Branche Wetlands in St. Charles Parish. The area is adjacent to the Lower Guide Levee of the Bonnet Carre' Floodway.

Resource Problem: The Bayou La Branche Wetlands consist of fresh and intermediate marshes on the south shore of Lake Pontchartrain. The close proximity of an abundant sediment source affords an ideal opportunity to restore these deteriorated areas of marsh.

Objective: The objective for this project is to create new vegetated wetlands and restore and nourish deteriorated marshes in the Bayou La Branche area.

Management Measures: The project involved dedicated dredging of sediments from Lake Pontchartrain to create vegetated wetlands in the area. The work consisted of pumping sediments from a bar located at the mouth of the Bonnet Carre' Floodway, adjacent to the marsh development site. Approximately 70 percent of the area was designated to hold sediment, kept in place with retention dikes. Dredge material was pumped to a height conducive to marsh development after a period of settlement and compaction. The area was seeded with Japanese millet by airplane. The project required approximately 18 months to complete and is considered successful. An evaluation by team members will determine if the dikes should receive more openings to improve the ingress/egress for marine organisms and the effectiveness of the land-to-water distribution.

Cost: Engineering and design and supervision and administration cost approximately $360,000 Oct. '91 P.L. ($403,200); project construction cost approximately $3,280,000 ($3,673,600); and supervision and inspection of construction contract(s) cost approximately $360,000 ($403,200). There is no operation and maintenance cost.

Outputs/Benefits: The project created approximately 254 acres of intermediate marsh and nourished an additional 87 existing acres. By the end of the 20-year project life, approximately 296 acres of marsh would remain in the project area. Additionally, the project could provide significant public outreach benefits, in that the project site is visible from U.S. Interstate Highway 10. The area is ideally situated for a demonstration project for marsh creation and restoration.

Marsh Protection - Lake Salvador Shoreline Protection
Jefferson Parish, Louisiana
New Orleans District

Location: The project is located on the eastern shore of Lake Salvador in Jefferson Parish, Louisiana.

Resource Problem: The Jean Lafitte National and Historical Park and Reserve is located east of Lake Salvador. The park consists mostly of fresh and intermediate marshes, cypress swamps and ridges of hardwood trees. The Bayou Segnette Waterway and a narrow isthmus of land separate the park and Lake Salvador. Wind generated waves from Lake Salvador are eroding the eastern shore of the lake and the western (right-descending) bank of the Bayou Segnette Waterway. At the most critical location, only a one (1)-foot wide, tree-lined bank separates Lake Salvador and the Bayou Segnette Waterway. Without shoreline protection, the eastern shore of Lake Salvador will continue to erode. The eventual breaching of the narrow point of land separating the Lake and the Bayou Segnette Waterway could allow wind-driven waves to erode the marshes of the park.

Objective: The objective for this project is to protect vegetated wetlands in the Jean Lafitte National and Historical Park and Preserve. Providing erosion protection for the eastern shore of Lake Salvador (the most critical section) will insure that the narrow isthmus separating Lake Salvador and Bayou Segnette is not breached exposing the wetlands of the park to wind generated wave erosion.

Management Measures: The project consists of constructing a 5,000-foot long multi- celled sand-filled fabric bag breakwater parallel to the eastern bank of Lake Salvador. The area between the breakwater and the existing shore would trap sediments from Lake Salvador; over time, emergent wetland vegetation could establish. An abandoned oil well access canal, just north of the proposed breakwater, is allowing water exchange between Lake Salvador and the Bayou Segnette Waterway. It is expected that this abandoned canal will grow progressively larger over time; consequently, closure (earthen closure) of the access canal is also a proposed project feature.

Cost: Engineering and design and supervision and administration will cost approximately $150,000 Oct. ‘91 P.L. ($168,000); estimated project construction cost $1,500,000 ($1,680,000); supervision and inspection of construction contract(s) will cost approximately $150,000 ($168,000); and replacement cost in project year 10 will cost approximately $676,000 ($757,120).

Outputs/Benefits: Stopping further erosion of the eastern bank of Lake Salvador would protect about 90 acres of fresh to intermediate marsh in the Jean Lafitte National and Historical Park and Preserve from being lost to wave erosion. Approximately 11 acres of new wetlands may develop between the proposed breakwater and the existing eastern bank of the lake.

Marsh Creation - Tiger Pass Maintenance Dredging
New Orleans District

Location: This project is located in Plaquemines Parish, Louisiana on 595 acres adjacent to a 2.1 mile channel reach at the mouth of Tiger Pass. Tiger Pass is one (1) of three (3) passes which bifurcate (divide into two (2) branches) from a break in the west bank of the Mississippi River known as "The Jump" located at Venice, Louisiana.

Resource Problem: The bar at the gulf entrance to Tiger Pass must be dredged for normal maintenance at approximately 2.5 to 3 year intervals. Normally, the dredged sediments would be used to create bird breeding islands near the bar area. Unfortunately, creation and maintenance of bird breeding islands has been difficult due to high wave energy in the unsheltered waters at the entrance to the channel. Transporting the material inland would allow marsh to be created in areas less subject to harsh wave attack, and allow better beneficial use of the available dredged material.

Objective: The objective for this project is to create vegetated wetland using sediments dredged for normal maintenance of Tiger Pass.

Management Measures: Tiger Pass is dredged from River mile 11.9 to River mile 14.0 once every 2.5 to 3 years. On average, approximately 1,097,000 cubic yards of sediment are removed from within the jetty and bar areas during each dredging cycle. Dredged sediments will be transported inland and deposited within shallow open water areas at an elevation conducive to marsh development. Sediments will be used to reestablish marsh lost to subsidence and erosion.

Dredging will be performed by hydraulic cutter-head pipeline dredge. The marsh development sites will be confined with the dredged material placed on both sides of Tiger Pass at an elevation of +4.0 feet NGVD. Dredged sediments will consolidate to a final design elevation of +1.5 feet NGVD to +2.5 feet NGVD. During the project life, dredged material will also be periodically used to nourish marsh previously created by loss to subsidence and erosion. On average, an additional 85 acres of marsh will be created every two and one-half (2 ½) to three (3) years.

Approximately three (3) months of pumping time would be required for the dredged material placement. An additional nine (9) months would be required for consolidation of the dredged material to the final design elevation.

To create marsh, dredged material must be pumped greater distances than would be the case for normal maintenance of the waterway and bar. Consequently, additional costs over present maintenance costs would be incurred.

Cost: Engineering and design and supervision and administration will cost approximately $5,000 Oct. '91 P.L. ($5,600); project construction will cost approximately $560,000 ($627,200); supervision and inspection of construction contract(s) will cost approximately $56,000 ($62,720); and operation and maintenance will cost approximately $175,000 ($196,000) which are costs over normal maintenance over a 20 year period.

Outputs/Benefits: Project implementation would create approximately 415 acres (net) of brackish and intermediate marsh by the end of the 20-year life of the proposed project.

Marsh Creation with Uncontrolled Sediment Diversion from the Mississippi River
West Bay Sediment Diversion - Plaquemines Parish, Louisiana
New Orleans District

Location: This project is located in Plaquemines Parish, Louisiana, approximately six (6) miles south of the city of Venice. The diversion site will be located on the right descending bank of the Mississippi River within the existing delta, 4.7 miles above Head of Passes (AHP). The project site consists of 12,910 acres of primarily shallow open water.

Resource Problem: Much of the land building capacity of the Mississippi River is being lost due to the discharge of sediments to the deep waters of the Gulf. This type of project will be a major tool in any maintenance or restoration effort in the Mississippi River delta. The current lack of significant fluvial overflow form the Mississippi River has been indicated as a primary cause for accelerating deterioration in Louisiana's coastal wetlands. Diversion projects provide a means of reestablishing these lost processes. Uncontrolled diversion projects of this size mimic a natural process on the scale of a river crevasse during a flood event or, in the venue of the delta, the opening of a new pass.

Small scale diversions or crevasses are presently in wide use within the delta and have been a primary tool for mitigation of both oil and gas, and federal navigation and flood control activities. These small-scale projects have proven to be very successful. Over a long period of time, repetitive use of these projects may be common. With this in mind, these diversion projects must be actively pursued.

The proposed project would recapture a small portion of the river's land building capacity that is currently being lost. Sediment diversion is an effective measure that can be implemented to create, nourish, and maintain wetlands.

Objective: The objective for this project is to create vegetated wetlands by diversion of sediments from the Mississippi River.

Management Measures: The project consists of construction of an earthen broad crested weir and conveyance channel. The initial construction will be based on a diversion of 20,000 cubic feet per second (cfs). After an operational trial period accompanied by intensive monitoring, the diversion cross-section will be enlarged to accommodate a design flow of 50,000 cfs.

The following features are included:

- Facility Relocations - A 10-inch diameter crude oil pipeline located on the west bank, runs parallel to the river at mile 4.7 AHP. About 1,500 linear feet of pipeline will be relocated.

- Construction of a Sediment Diversion Channel and Weir - The initial sediment diversion channel will be dredged to a depth of -45.0 feet NGVD and have a bottom width of 30 feet and side slopes of 1V on 3H. Construction of the diversion channel and weir will be accomplished by hydraulic pipeline dredge. Excavation of approximately 650,000 cubic yards of material will be required for the initial 20,000 cfs design diversion. Phase 2 of the construction will consist of excavating approximately 1,450,000 cubic yards of material to achieve the final 50,000 cfs design section. The excavated material will be hydraulically transported and placed along the marsh side of the existing river banks and pumped to an elevation of +4.0 feet to +4.5 feet NGVD conducive to marsh creation.

- Construction of Sediment Retention Dikes - To further enhance the development of marsh within the receiving waters, earthen dikes would be constructed within these waters to assist in retaining discharge sediments.

- Project Monitoring - This intensive program will be operational for a period of one (1) (or more) high water seasons to observe diversion operations at the 20,000 cfs design level. The monitoring program will provide for hydrographic surveys, discharge measurements for developing and verifying diversion rating curves, aerial photography, sediment concentration measurements, sediment plume studies, etc, as necessary, to assess the efficacy of diversion operations and indicate desired design modifications for full-scale diversions. A long-term monitoring program will become operational after full-scale diversions are implemented.

- Bifurcation Dredging - Additional bifurcations would be dredged in the new delta that would be formed, as required, to help maintain optimal performance of the large-scale sediment diversion and assist in extending the growth of the delta.

- Contingency Closure - It is possible that during sediment diversion operations, the theoretical cross section of the diversion channel could increase due to scour caused by diverted flows from the Mississippi River. In the event that during the project life the original diversion channel cross-sectional area were to enlarge by approximately 50 percent, contingency plans for closing off the diversion would be initiated.

Cost: Engineering and design and supervision and administration will cost approximately $115,000 Oct. '91 P.L. ($128,800); project construction will cost approximately $2,375,000 ($2,660,000); supervision and inspection of construction contract(s) will cost approximately $154,000 ($172,480); operation and maintenance (average annual costs and over normal maintenance and duration over 20 years) will cost approximately $36,000 ($40,320); and project monitoring will cost approximately $54,300 ($60,816) per year.

Outputs/Benefits: Project implementation would create approximately 9,830 acres of fresh to intermediate marsh over the 20-year life of the proposed project while benefitting an additional 890 acres annually, which translates to an annual average of 4,912 habitat units.

Mississippi River Gulf Outlet (MRGO) Disposal Area Marsh Protection
New Orleans District

Location: The project is located in St. Bernard Parish on the existing south bank disposal area for the MRGO, south of the Bayou La Loutre Ridge, from approximate River mile 36.0 to River mile 30.0 along the MRGO. The project area consist of an 855-acre fresh marsh, perched one (1) to four (4) feet higher than the adjacent brackish marsh.

Resource Problem: The project area consists of a 4,000-foot-wide diked disposal area originally utilized for placement of dredged material during construction of the MRGO in the early 1960s. During maintenance dredging operations, only the 2,000 feet nearest the waterway has been used. The rear, or back, 2,000 feet has reverted to a high fresh marsh, especially south of the Bayou La Loutre Ridge as a result of the disposal material settling and water ponding. These marshes are elevated one (1) to four (4) feet higher than the adjacent brackish marsh. This wetland area is extremely valuable for waterfowl.

Objective: The objective for this project is to protect and preserve these vegetated wetlands.

Management Measure: The back dike of the MRGO disposal area will be repaired south of the La Loutre ridge. Culverts will be placed in the levees to control water levels within the units.

Costs: The cost of this project is approximately $434,000 Oct. '93 P.L. ($460,040). The estimated cost per benefitted acre is $575 ($610).

Outputs/Benefits: Project implementation will preserve over 755 acres of marsh that will be lost within 20 years if no action is taken and the disposal area drains and converts to an upland habitat type. Because the project area is one (1) to four (4) feet higher than the adjacent brackish marshes, marine organisms have no access into the area; however, this fresh perched marsh is an excellent habitat for migratory waterfowl.

Pass a Loutre Crevasse
New Orleans District

Location: The crevasse cut will be located near the head of Pass a Loutre on the north side of Head of Passes in the Mississippi River Delta, Plaquemines Parish, Louisiana. The area encompasses 1,870 acres of primarily shallow open water bottom and is bounded on the north side by Raphael Pass and to the west by the main river channel.

Resource Problem: The area, north of Pass a Loutre and east of the Mississippi River, no longer receives marsh nourishing sediment from the river due to the enhancement of the bank line. The mouth of Pass a Loutre is routinely used as a hopper dredge disposal area. The additional material placed into this pass is retained in the channel bed, usually until the low water season, at which time the material is scoured away and carried out to the mouth of the pass. Once the material is deposited near the mouth of Pass a Loutre, it is generally reworked by the high wave energy, and as a result, fails to develop new sub-aerial delta.

Objective: The objective of this project is to utilize available sediment in areas which are currently shallow open water bottoms to create emergent marsh. In addition, the material excavated in constructing the crevasse channel will be placed to immediately create new wetlands.

Management Measure: The proposed site would be in the vicinity of the original Pass a Loutre Sediment Mining project site. This site would allow the cut to take flow from the main river channel just to the north of the mouth of Pass a Loutre. The cut would angle along the mouth of Pass a Loutre cutting through a point bar before breaching the channel bank just downstream of the mouth of the pass.

The project will consist of a conveyance channel of approximately 3,500 feet with a bottom width of 430 feet and an invert elevation of -6.0 feet NGVD. This channel should provide an average flow of 2,500 cfs. The construction will consist of hydraulically dredging approximately 550,000 cubic yards of material from Pass a Loutre and the adjacent bank and placing it in an unconfined disposal site. The material will be placed at an elevation no higher than +2.5 feet NGVD and will result in an initial creation of 86 acres of emergent wetlands.

Costs: This project will cost approximately $2,242,000 Oct. '93 P.L. ($2,376,520). This estimated cost includes 25 percent contingencies as well as 12.5 percent engineering and design cost and 11.5 percent of supervision and administration costs. Monitoring costs for this type of project have been estimated at $8,625 ($9,142) per year under the Coastal Wetlands Planning, Protection and Restoration Act monitoring criteria.

Outputs/Benefits: The project is projected to create approximately 900 acres of marsh over its 20-year life.

West Belle Pass Headland Restoration
New Orleans District

Location: The project area is 2,459 acres of coastal wetlands located just west of Port Fouchon, Lafourche Parish, Louisiana. The project area is bound by Timbalier Bay on the west, Bayou Lafourche and Belle Pass to the east, and the Gulf of Mexico to the South.

Resource Problems: Timbalier Bay is encroaching into the marshes on the west side of Bayou Lafourche and wave action is eroding the banks of Bayou Lafourche. Openings along the banks of Bayou Lafourche are causing tidal scour in the interior marshes of the project area.

Objective: The objective of this project is to reduce the encroachment of Timbalier Bay into the marshes on the west side of Bayou Lafourche with the use of dedicated dredged materials to create wetlands, and by constructing dams and controlling channel cross sections. The rate of tidal exchange will be lessened allowing created and existing marsh to stabilize. The project will also reduce the shoreline erosion along the west bank of Bayou Lafourche and Belle Pass.

Management Measures: Approximately 2,700,000 cubic yards of material will be dredged from Bayou Lafourche and used to build approximately 184 acres of marsh on the west side of Belle Pass. A water control structure in the Evans Canal and plugs on other canals will reduce tidal influence within the project area. Riprap will be placed on the west side of Belle Pass and Bayou Lafourche from the jetty north 17,000 feet to reduce the shoreline erosion into the wetlands.

Costs: The estimated total project cost is $4,187,375 Aug. '92 P.L. ($4,564,239). The operation and maintenance cost at year 10 will be approximately $150,000 ($163,500) and the monitoring cost will be approximately $4,325 ($4,714) per year.

Outputs/Benefits: The project area contains saline marsh and black mangrove wetlands. The entire 2,459 acre project area would be enhanced by creation of new marsh and preservation of existing marsh. Approximately 184 acres of saline marsh would be created. This project would prevent the loss of approximately 436 acres of saline marsh. The project life is 20 years; however, benefits would continue at the end of the project's life. Average annual habitat units for this project is 216 with a cost per habitat unit of $2,325 ($2,534).

CHAPTER V - FLOOD CONTROL PROJECTS WITH ENVIRONMENTAL FEATURES

Seven (7) USACE projects discussed in this chapter are all associated with flood damage reduction. Two (2) of these projects use the Stream Obstruction Removal Guidelines (SORG) form the American Fisheries Society in cooperation with International Association of Fish and Wildlife Agencies to develop their National Economic Development (NED) plan. The other five (5) studies included in this chapter cover a diversity of project types which include: flood control with habitat restoration, habitat restoration as part of reconstruction of flood control facilities, redesign of a flood control project to achieve an environmentally sensitive solution, mitigation, and flood control.

BLACK RIVER, OBSTRUCTION REMOVAL, SECTION 205 BUTLER COUNTY, MISSOURI
Little Rock District

Location: Butler County, Missouri, is located in the extreme southeastern part of Missouri, and is primarily a rural area. The study area is located in the wide alluvial valley of the Black River. This segment of the river is sinuous with a streambed slope of about 0.7 foot per mile and composed mostly of sand and silt with some gravel. Black River Ditch, an improved channel, which extends along the right bank of the Black River from approximate River miles 191 to 171, was formed as the borrow area for the Levee District No. 7 levee. Black River Ditch is an interceptor ditch for Main Ditch, Big and Little Hunting Sloughs, Stilcamp Ditch, and Dan River. The Levee District No. 7 levee extends along the right bank of the Black River from near Poplar Bluff, Missouri, to the Missouri-Arkansas State line. This levee is subject to frequent damage from the Black River flooding near River miles 191 and 186. The land bordering this reach is flat farmland and is about 95 percent cleared.

Swift Ditch, an interceptor ditch along the left bank of Black River, was formed by excavation to provide a levee for protection of these lands. Swift Ditch and Black River are connected at several places, the largest connection is at River mile 192.0. From that point until the ditch and the river converge at River mile 184.0, Swift Ditch carries about 60 percent of the combined flow of the two (2) streams. A considerable amount of fishing occurs in Swift Ditch.

The project begins just upstream of the Hargrove Bridge (River mile 198.4), approximately six (6) miles south of Poplar Bluff and extends to the Arkansas State Line (River mile 170.9).

Flooding Problems: Major flooding of agricultural fields adjacent to the Black River and its tributary ditches occurs mostly in the spring, but may also occur in the fall and winter. Damages are in the form of lost crops or delays of planting/harvesting. State Highway 53 is routinely flooded from high water from the Black River as is nearby Coon Island Wildlife Management Area. Average annual flood losses of over $2 M ($2.3 M) occur in the area.

Clearwater Lake is designed to release flood storage at levels which meet the 11-foot gauge at Poplar Bluff. Releases from Clearwater Lake which top the 6.5-foot gauge at Poplar Bluff now cause flooding of the agricultural fields adjacent to the Black River. This problem is directly attributable to the decrease in channel capacity resulting from the silted-in log jams and large snags on the river and its tributary ditches. Numerous obstructions, in the form of trees, log jams, and leaves mixed with silt, are located within the channel throughout the downstream reach. Public use areas at Clearwater are also being affected by these sustained high flood pool levels.

The project area is primarily mixed bottomland hardwood species. The surrounding area is in agricultural crops such as rice and wheat. Clearing the timber and draining of the lowlands for agriculture has increased both sedimentation and water temperature, which has, in turn, negatively impacted the original warm water fishery. Most fish species are those characteristic of standing water and tolerant of aquatic vegetation. Their distribution seems to be a function of topographic relief and stream gradient. Deer, squirrel, and waterfowl are the most hunted species in the Black River basin; however, rabbits, turkeys, and various fur-bearing species of wildlife are also present.

Objectives: The following objectives were developed for this project.

- Contribute to the reduction in flood damages to crops and property in the floodplain of the Black River in Butler County
- Contribute to the public health, safety, and social well being of persons living in the flood-prone areas encompassed by the project by reducing trauma and anxiety caused by flooding
- Contribute to the preservation of environmental resources in the study area

Planning Constraints: The first two (2) planning constraints listed below are applicable to the Black River flood damage reduction project. The last three (3) listed affect the implementation of the study recommendation.

- The study is geographically limited to addressing flood damage reduction in Butler County, Missouri

- Major channel modifications, such as enlargement and straightening, are strongly opposed by the Missouri Department of Conservation, the Missouri Department of Natural Resources, and the U.S. Fish and Wildlife Service

- Federal construction expenditures for flood damage reduction measures under this authority (Section 205) will not exceed $5,000,000

- The selected plan must be complete within itself and fully effective, obligating the Federal Government to no future work to make the project function as designed; accordingly, operation and maintenance of the project after completion are local responsibilities

- Local interests are required to provide all lands, easements and rights-of-way, and also must provide a cash contribution equal to at least 5 percent of the total cost

Management Measures Considered: The following plans were considered for this project:

- Channel clearing and dredging on the Black River
- Extensive clearing and snagging on the Black River
- Major obstruction removal on the Black River and Swift Ditch following the American Fisheries Society (AFS) guidelines (also known as the Stream Obstruction Removal Guidelines - SORG)
- Major obstruction removal only on the Black River following the AFS guidelines

The first two (2) plans listed were determined to be environmentally and economically infeasible and were not costed. The last two plans listed were costed, since they both initially appeared to be environmentally sustainable. The last plan listed produced greater net benefits and represents the NED plan.

According to the Water Operations Technical Support (WOTS) received from WES, obstruction removal from Swift Ditch was eliminated due to the following major undesirable effects.

- Clearing Swift Ditch would cause it to capture almost the entire flow of Black River very quickly, even if structural measures (weirs or dikes) were constructed to restrict low flows. One attempt had been made to close Swift Ditch during the early 1930s. Five dikes were installed and were promptly flanked by high flows during flood events. Capture by Swift Ditch would quickly reduce the Black River (River miles 192.2 to 184.0) to a backwater slough. This plan is unacceptable to the conservation agencies in Missouri.
- Increased flows down Swift Ditch would cause additional widening, deepening, and meandering. This would produce additional erosion and damage to the Drainage District Levee unless a major bank protection effort was undertaken. Even if the levee could be protected, it would not prevent the negative impacts to the Black River.

Due to the findings in regards to Swift Ditch, the selected plan, which is the last plan listed above, was the only environmentally acceptable plan as well as the NED plan.

Selected Plan: The selected plan consists of removing all Condition Three and some Condition Two blockages (definitions of "Conditions" will be discussed later) from River mile 198.4 just upstream from the Hargrove Bridge to the Arkansas State Line (River mile 170.9) and the cutting

of excessively leaning (more than 30 degrees off vertical) and undercut streambank trees in the upstream and downstream portions of the Black River (above and below Swift Ditch). It is estimated that 10 percent of streambank trees would have to be cut using this selection criteria. No Condition Four blockages were identified. No dredging of the channel will be performed.

The basic goal of the selected plan is to restore Black River channel capacity with a minimum disturbance to the riparian ecosystem. Due to the past opposition by the U.S. Fish and Wildlife Service and the State of Missouri's Conservation Agencies (MDC and DNR), extensive clearing of the streambank channel modification would not be performed. Log jams would be taken apart and individual trees cut into two (2)-foot lengths from the channel. Other trees could be securely cabled along the streambank to reduce erosion of the streambank and provide fishery habitat. Overhanging trees at an angle of 30 degrees or more off vertical would be cut off, but the stump would be left in place to reduce bank erosion. Approximately 3,300 trees are cited for removal. All work in this area would be done using hand tools from a flat bottom boat in the river channel. No mechanical dredging of the channel would be done.

The definitions of potential obstructions and Conditions Two, Three, and Four from the SORG manual are described in the following paragraphs along with the approximate number of trees to be removed for this project for each Condition.

Potential Obstructions: Removal of approximately 10 percent of trees within channel banks with an average diameter of eight (8) inches. Total number of trees to be removed in this project area is approximately 1,400.

Condition Two: These stream segments currently have no major flow impediments, but existing conditions are such that obstructions are likely to form in the near future, causing unacceptable problems. This condition is generally characterized by small accumulations of logs and/or other debris which occasionally span the entire stream width. Accumulations are isolated, not massive and do not presently cause upstream ponding damages. Approximately 1,000 trees are to be removed under this condition.

Condition Three: These stream segments have unacceptable flow problems. Obstructions are generally characterized by large accumulations of lodged trees, root wads, and/or other debris that frequently span the entire stream width. Although impeded, some flow moves through the obstruction. Large amounts of fine sediment have not covered or lodged in the obstruction. Approximately 865 trees are to be removed under this condition.

Condition Four: These stream segments are characterized by major blockages causing unacceptable flow problems. Obstructions consist of compacted debris and/or sediment that severely restricts flow. As mentioned above, this condition is not identified in this project area.

Costs: The project first cost is estimated at $355,600 Jul. '90 P.L. ($405,384) with Operation and Maintenance Cost of $7,000 ($7,980) per year.

Outputs/Benefits: The selected plan would provide about $139,100 ($158,574) in average annual flood reduction benefits. Average annual flood losses would decrease from the current $1,874,100 ($2,136,474) to about $1,735,000 ($1,977,900). Although flood damages would still occur, those damages would be less than now experienced and less frequent. Agricultural annual benefits would be $92,300 ($105,222), and rural structural annual benefits would be $46,800 ($53,352).

According to the user data provided by the Missouri DNC, there is heavy fisherman use of this portion of the Black River. It has not yet been determined what quantitative impact the project would have, although, it is likely that the improved navigability of the river would increase fisherman use.

STREAM OBSTRUCTION REMOVAL GUIDELINES (SORG)

The following section is from the Black River, Obstruction Removal, Section 205 report, previously discussed, which addresses the SORG guidelines in more detail. For more information about SORG, contact the American Fisheries Society.

A. General guidelines. No stream work, including bank clearing and excavation or removal of materials, should be allowed, except at specific locations where significant blockages occur. Channel excavation and snag removal should be accomplished with the minimum clearing possible to provide access to the stream.

B. Materials to be removed from the channel.

(1) Log Jams - Only those log accumulations that are obstructing flows to a degree that results in significant ponding or sediment deposition should be removed.

(2) Other Logs

> (A) Affixed Logs - Isolated or single logs will not be disturbed if they are embedded, jammed, rooted or waterlogged in the channel or the floodplain, are not subject to displacement by current, and are not presently blocking flows. Generally, embedded logs that are parallel to the channel are not considered to cause blockage problems and will not be removed. Affixed logs, that are crossways to the flow of waters in the channel and are trapping debris to the extent that could result in significant flooding or sedimentation, may be removed.

(B) Free Logs - All logs that are not rooted, embedded, jammed, or sufficiently waterlogged to resist movement by river currents may be removed from the channel.

(3) Rooted Trees. No rooted trees, whether dead or alive, should be cut unless:

(A) They are leaning over the channel at an angle greater than 30 degrees off vertical, and they are dead or dying, have severely undercut or damaged root systems, or are relying upon adjacent vegetation for support, and it appears they will fall into the channel within one (1) year and create a blockage to flows; or

(B) Their removal from the floodplain is required to secure access for equipment to a point where a significant blockage has been selected for removal.

(4) Small Debris Accumulation - Small debris accumulations should be left undisturbed unless they are collected around a log or blockage that should be removed. (It is felt that small debris accumulations will not constitute a significant blockage to flows. Upon removal of logs and other blockages, under these guidelines and following completion of the project, the changed water velocities would remove and disperse these small debris accumulations and no significant blockage of water flows will result.)

C. Work Procedures and Equipment to be Used.

(1) Log Removal - First consideration will be given to the use of hand operated equipment to remove log accumulations. When the use of hand-operated equipment is not feasible, vehicular equipment may be used under the following restrictions and guidelines:

(A) Water-based equipment (e.g., a crane or winch mounted on a small, shallow draft barge or other vessel) should be used for removing material from the streams. A small crawler tractor with winch or similar equipment may be used to remove debris from the channel to selected disposal points.

(B) When it can be demonstrated that stream conditions are inadequate for the use of water-based equipment, the smallest feasible equipment with tracking systems that minimize ground disturbance will be specified for use. Larger equipment may be employed from non-wooded areas where cables could be stretched down to the channel to drag out materials to be removed.

(C) Access routes for equipment should be selected to minimize disturbance to existing floodplain vegetation, particularly in the riparian zone. Equipment should be selected which will require little or no tree removal to maneuver in forested areas.

(2) Rooted Trees - Whether dead or alive, rooted trees selected for removal shall be cut well above the base, leaving the stump and roots undisturbed. Procedures for removing the felled portion will be the same as for other logs.

(3) Log Disposal - General - All logs or trees designated for removal from the stream or floodway shall be removed or secured in such a manner as to preclude their re-entry into the channel by floodwaters. Generally, they will be transported away from the channel, so as to reduce flood flow impediment. Where large numbers of logs are moved at one location (e.g., log jams), burning may be the most feasible disposal technique. Burying of removed material should not be allowed.

(4) Sediment Blockages - The magnitude of some blockages necessitates the use of conventional excavating equipment. This equipment should be employed in a manner which will minimize environmental damages.

(A) Access routes for equipment should be selected to minimize disturbance to exiting floodplain vegetation, particularly in the riparian zone.

(B) Material disposal and necessary tree removal should be limited to one side of the original channel at any given location.

(C) To the maximum extent possible, excavating equipment should be employed in the channel bed.

(D) Where feasible, excavated materials should be removed from the floodplain. If floodplain disposal is the only feasible alternative, disposed material should be placed on the highest practical elevation and no materials should be placed in any tributary or distributary channels.

(E) No continuous disposal pile should be created. It is suggested that no pile exceed fifty (50) feet in length or width and a gap of equal or greater length should be left between adjacent disposal piles.

(F) Disposal piles should be constructed as high as sediment properties allow.

(G) The placement of disposed material around the bases of mature trees should be avoided where possible.

D. Reclamation Measures.

All disturbed areas should be reseeded or replanted with plant species which will stabilize soils and benefit wildlife. Revegetation should be in accordance with recommendations of the MDC and DNR.

Disposal Areas. Increased river flows will remove the accumulated sediment once the log jams have been removed. As stated prior, no channel dredging is anticipated. A reasonable effort shall be made to place materials of value into beneficial use. In areas where trees can be used to help stabilize the river channel, they will be cabled securely against the river bank. All other trees will be cut into two (2) foot lengths and either removed from the floodway or piled no closer than 15 feet to top of bank of the river channel. This material can later be utilized as firewood or left on the river bank to decompose. Wooded areas will not be cleared to provide disposal areas.

MAYFIELD CREEK, KENTUCKY - SECTION 205
Memphis District

Location: The study area is located in Carlisle, Ballard and McCraken counties in western Kentucky, near Paducah, Kentucky. Mayfield Creek is a tributary to the Mississippi River.

Resource Problem: The floodplain consists of both croplands and environmentally sensitive wetlands, invaluable bottomland hardwoods, and marsh and swamplands. Its water resources problems and needs relate directly to stream flow deterioration and reflect a serious wetness problem affecting not only agricultural lands but valuable bottomland hardwoods as well. The primary problem in the basin is frequent headwater flooding of agricultural and bottomland hardwood areas along the lower 25 miles of the creek.

The increase in erosion resulting from inadequate or poor farming practices has contributed to the formation of large silt deposits in the channel that now block most flows in some portions of the stream. In addition, vegetative overgrowth and debris have further reduced the flow carrying capacity of the channel. Floodwaters that would normally be transported downstream now inundate the surrounding area along the creek and eventually cause wetness conditions that are detrimental to cropland and standing timber. In the period 1950 to 1983, approximately 4,700 acres of cropland and bottomland hardwoods evolved to marshes and swamps as a direct result of sediment deposition caused by upland erosion and lack of channel capacity.

Objectives: The following planning objectives were established to address the resource problems, realize the opportunities identified in the Mayfield Creek basin, and to serve as guidelines for the formulation and evaluation of alternative plans.

- Reduce flood problems in the Mayfield Creek basin to promote economic development and preserve environmental resources

- Protect fish and wildlife habitat along Mayfield Creek and its tributaries

Management Measures Considered: Within the framework of plan formulation criteria, a wide variety of plans of improvement were identified to meet the planning objectives for flood control and fish and wildlife. Many of the alternatives were eliminated from further consideration because of limited economic feasibility, significant environmental problems, or limited potential for providing solutions to flooding. The alternatives that were retained provide the basis for selecting the plan that best meets the planning goals and objectives.

No Alternative. There would be no relief from the flooding that has existed in the past. Flooding and wet conditions would continue to worsen in the future causing damage to crops, standing timber and other developments in the study area.

Non-Structural Alternatives. Non-structural alternatives are those which reduce or avoid flood damages without significantly altering the nature or extent of flooding by changing the use made of the floodplain or accommodating existing uses to the flood hazard. Traditional non-structural alternatives such as floodproofing structures, permanent floodplain evacuation, and flood forecasting are not effective in relieving flood damages to croplands and timberlands, which are the primary areas subject to flooding in the lower Mayfield Creek basin. For this reason, non-structural alternatives were not further considered.

Structural Alternatives. Structural alternatives differ from non-structural alternatives in that they actually modify flood flows in the problem area. Several structural alternatives were considered in the initial stages of plan formulation, including vegetative clearing and snagging, channel improvements according to the "Stream Obstruction Removal Guidelines" (SORG), channel enlargement, and channel clean out. Brief descriptions of these alternatives are presented in the following paragraphs.

Vegetative Clearing and Snagging. Clearing and snagging involves the removal of debris, vegetative overgrowth, snags and drifts in the channel to provide a more efficient passage for flood flows. Clearing Mayfield Creek from River miles 0.0 to 25.0 was studied in detail.

Channel Improvement (SORG). Channel improvement according to SORG involves selective removal of vegetative growth, snags, drifts and sediment deposits to aid the passage of stream flows and maintain natural stream characteristics. The purpose of this alternative is to improve the flood carrying capacity of the channel, while lessening the adverse environmental impacts that are often associated with structural channel enlargement alternatives. Overall, this plan addresses both objectives of flood control and fish and wildlife protection. Guidelines were used to formulate this alternative which involved classification of obstructions into several condition categories and specifying the extent and methods of obstruction removal by an interdisciplinary team.

Channel Enlargement. This alternative would involve enlarging the existing channel bottom from approximately 50 feet to 60 to 90 feet, along the lower 25.6 miles of Mayfield Creek. Approximately 10,000,000 cubic yards of material would be excavated with this alternative.

Channel Clean Out. This alternative was formulated to assist in bracketing the NED plan. Only detailed engineering studies were performed on this alternative because of time limitations. This plan would consist of clearing and snagging the lower 6.1 miles and sediment clean out in the upper reaches of the creek. Approximately 2,291,000 cubic yards of sediment would be excavated with this alternative.

Selected Alternative: The SORG alternative is the NED/recommended plan. It was the only plan found to be economically feasible; it is the most environmentally sensitive plan; it is the plan most favored by the non-Federal sponsor; and it is in the Federal interest to implement.

The recommended plan would be implemented with two (2) items of work. Item 1 would consist of selective clearing and snagging of channel debris according to SORG from River miles 0.0 to 8.0. Item 2 would consist of selective clearing and snagging of channel debris and excavation of approximately 178,000 cubic yards of sediment, according to SORG, from River miles 8.0 to 25.0. Channel protection would be required at six (6) highway bridge crossings and one (1) natural gas pipeline crossing due to increased channel velocities under project conditions. A low-flow weir would be constructed just above the confluence of Wilson Creek to divert water into an old channel meander that has been identified as a valuable fisheries habitat. No relocations are expected to be required with implementation of this alternative. The SORG alternative would shorten the duration of flooding and provide increased drainage potential in the lower Mayfield Creek basin, but would not affect peak flood flow lines. The primary benefits expected to accrue to this alternative are cropland and bottomland hardwood intensification and inundation damage reduction to croplands and roads.

Costs: The estimated total cost for this project is $2,061,000 Jan. '90 P.L. ($2,370,150).

Outputs/Benefits: Inundation benefits are expected to accrue to croplands and roads. Intensification benefits result from the placement into production of row crops and timber on lands sustaining excess soil moisture in the absence of a project. Other benefits would include increases in fish and wildlife recreation activities and land values.

JACKSON HOLE, WYOMING - FLOOD DAMAGE REDUCTION AND FISH & WILDLIFE HABITAT RESTORATION
Walla Walla District

A Feasibility Study Cost Sharing Agreement and Project Study Plan have been completed, dated July 1996 for the Jackson Hole, Wyoming - Flood Damage Reduction and Fish & Wildlife Habitat Restoration. The Project Study Plan documents the assumptions, work tasks, products, and the level of detail that will be necessary during the Feasibility Study to determine the existing and the future without project conditions; formulate a wide range of alternatives; assess their effects; and present a clear rationale for the selection of water resource development and environmental restoration plan(s).

The following information was obtained from the Jackson Hole, Wyoming - Flood Damage Reduction and Fish & Wildlife Habitat Restoration Reconnaissance Report dated June 1993. This report contained various management measures and their costs and was deemed meaningful to use for the *National Review of Corps Environmental Restoration Projects* report. This does not necessarily connote that the following management measures will be used for the Jackson Hole study.

Location: Jackson Hole, Wyoming, is part of the 18-million-acre Greater Yellowstone ecosystem surrounding the world's first national park. The area, rich with unique plant and animal species, is one of the nation's prized environmental resources. Recent discovery of the Northern Rocky Mountain Wolf confirms that all of the animal species that were present in Jackson Hole when European man set foot on this continent are present now.

The Snake River bisects this region, providing the ecosystem with water, a critical component. The area's rivers historically occupied wide floodplains and were highly braided, which is nature's way of dissipating energy resulting from high water velocities associated with the area's steep river slopes.

The study area was limited to four (4) specific sites within the "active" river of the Snake River in the Jackson Hole, Wyoming, area. This area lies between Moose, Wyoming, near the southern boundary of Grand Teton National Park, and the U.S. Highway 26 Bridge over the Snake, River about seven (7) miles south of Jackson, Wyoming.

Resource Problems: Through time, regional hydrological changes have occurred. The Snake River has been confined and straightened by levees that modify river hydraulics and concentrate flows. Restriction of the braided-channel pattern has resulted in higher flow concentration and, possibly, higher velocities. The disruption of the random pattern of braided channels has resulted in more frequent attack on the islands remaining within the levee reach. Eroded materials are carried downstream as sediment and are deposited in a lower-velocity river reach.

These ecosystem changes have caused the deterioration of critical habitat for endangered species and the slow, but steady, loss of a significant national resource.

Areas within the natural floodplains of the Snake and Gros Ventre Rivers are susceptible to damage from bank erosion, overbank flooding, and avulsion. This is because the levee system is discontinuous, and some levee sections provide less than 100-year flood protection. Floodplain areas susceptible to damage include developed and undeveloped land and valuable fish and wildlife habitat. While local interests have long expressed support for extending or completing the levee system to protect property and habitat, over time the levees have significantly changed the physical character of the river system and contributed to the loss of valued environmental resources.

Until the river reach was constrained by the levees, multiple main channels and numerous secondary branches spread out over a floodplain up to 8,000 feet wide. The secondary channels became active during floods, spreading the flow over a wide area. Once the continuous system of Federal levees had been completed along a 13-mile-long reach of the river, channel migration and avulsion were limited to the area between the levees, concentrating the discharge in the existing main channels and increasing the frequency of attack on vegetated areas. Furthermore, while this portion of the system would be expected to build up sediment under natural conditions, it is actually eroding, because of the confined flow induced by the levees.

Aquatic habitat effects associated with the levees include:

- Loss of spawning area for the fine spotted cutthroat trout in the spring creeks
- Difficult passage to spring creeks for spawning
- Loss of low-energy habitat as a result of increased velocities in the main channels

The physical changes produced by the levees have disturbed the wetland and riparian ecology in several ways. Adverse effects include:

- Loss of wetland and riparian vegetation in areas cut off from periodic flood flows
- Erosion of vegetated areas between the levees and downstream of the levees
- Conversion of riparian forest stands to drier and less diverse forest types
- Lack of regeneration of valuable cottonwood stands

Flood protection provided by the levees has contributed to development in the floodplain, which has resulted in clearing of vegetation, disturbance of wildlife, and introduction of exotic plant species.

Assessment of expected future conditions for the study area indicates that there will likely be continuing development pressure in the floodplain behind the levees. Future development will continue to result in habitat losses and disturbance of wildlife. Conversely, however, individual lots

are typically larger, recreational values associated with study area resources are increasing, and there is greater interest in environmental diversity and resource protection.

Additional development in the future will result in more pressure for levees in floodplain areas that are currently unprotected. The physical changes associated with the existing levees will continue, resulting in further erosion between the levees and likely increases in O&M costs. Maintenance of the levee system will also depend on increasingly expensive quarry rock for riprap. Along with erosion and related changes in the river, effects on surface and possibly groundwater hydrology will result in continuing environmental damage. Without both flood protection and environmental restoration actions, there will be greater local discontent with the Federal government and the Corps.

Objectives: The objectives for this project are:

- Reduce future economic losses from bank erosion, overbank flooding, and avulsion along the Snake River and tributaries

- Restore fish and wildlife habitat resources to modern historical conditions, using a bioregional approach; reverse the adverse impacts of Corps activities and restore habitats to previous levels of productivity, but not a higher level than would have existed under natural conditions in the absence of human activity or disturbance

- Identify the short-term measures that could be implemented to comply with recommendation made by the FWS under Section 7 of the Endangered Species Act (ESA)

Management Measures: Extending the upper left bank Federal levee downstream to the Gros Ventre confluence and raising the Gros Ventre non-Federal levees to provide 100-year protection warrant more detailed investigation. In addition, the reconnaissance study concluded that the benefits of extending the existing Federal levee system on the Snake River downstream to the U.S. Highway 26 Bridge at South Park should be re-evaluated in the feasibility study.

Eight (8) types of alternative plans to restore fish and wildlife habitat were recommended for feasibility level of study which include:

- Sediment Redistribution - Gravels and cobbles can provide stable substrates if placed on the proper slope. Cobbles and gravels would be placed on gradual slopes of 1V on 4 H or greater and constructed to an elevation that would reduce the frequency of overtopping and encourage vegetation growth. Coarser material (larger cobbles) would be used for side slopes and finer materials (gravels and sediments) would be used on tops. Small berms or training fences could be used to trap additional sediment to encourage plant growth.

- River Training Fences - Wood or timber fences would be placed to deflect river flows away from and around islands under attack. Deflection fences consist of posts, spaced at close interval, and planks, placed horizontally, with planks fastened directly to the posts as close together as possible without totally obstructing the flow. Posts would be 12 to 18 inches in diameter, and rails should be at least two (2) to four (4) inches thick, depending on post spacing. The sediment-laden water penetrating the fence is slowed sufficiently to drop the heavier fraction of entrained soil on the downstream side. The energy-reducing mechanism is primarily the head loss from penetrating the fence twice; first to get into the bank zone and again to get out. If the protected reach is long enough and steep enough to support the rapid flow, it must be subdivided with additional fences or structures (gravel berms) to further impede flow. Wooden structures will eventually rot away above the low water line, leaving only the new bank above ground. Permanently submerged timber will remain to provide scour protection for many years.

- Rock Spur Dikes - These would be constructed as short extensions of the dike, on the order of 15 to 50 feet in length. They would extend into the river to cause irregularities in the bank and adjacent river flow. The crest would be 10 feet wide and extend from near the top of the levee to the ned of the dike, which would be constructed about two (2) feet above normal low water. The foundation would be at least six (6) feet deep, with the end of the dike reaching down 10 feet in anticipation of the aggravated scour. Spur dikes may be placed along levees in groups to enhance protection of the levee.

- Wood Spur Dikes - These would provide the same values and functions as rock spur dikes but at a much lesser cost. Treated timbers, which are environmentally approved for in-water use, or cedar or other natural woods resistant to decay, could be driven into the river bottom to serve as an energy dissipator.

- Boulder Placement - These could be placed in critical places around islands, to protect banks, and in midstream areas to provide fish resting areas. In most cases, this method would only slow the erosion process because boulders tend to settle into self-induced scour holes and disappear. Some success has been reported with groups sited carefully to avoid the main current and "tie-off" to high ground or other structures.

- Root Ball Placement - These would be embedded near an island or levee and will deflect river flow against the bank. The stem will cause the snag to face downstream and resist forces to remove it. Their buoyancy even prevents them from being sucked into the scour holes they create.

- Channel restoration - To increase the channel diversity and area, pilot channels should be excavated through these islands to encourage fresh meanders. For this stage of the study process, it was assumed that a typical channel would be approximately 100 feet wide at

ground-line, about 80 feet wide at water-line, and about three (3) to five (5) feet deep at low flow. The excavated gravel would be laid back in a low berm on the upland portion of the island or used for small levees to induce additional sediment buildup.

- Floodplain habitat development - A number of headgate structures placed in the levees at the time of construction have gone dry because of river bed erosion. Earthwork in the river channel or relocation of the channel could direct water back to these intake structures. This would allow water to re-enter alluvial channels, recharge the groundwater, and provide a source of soil moisture. Flood gates or head gates have the potential to provide two (2) distinctly different opportunities for floodplain habitat development. Head gates could be constructed to provide flow to alluvial channels cut off by the levees, to restore lost aquatic habitat. Alternatively, floodgates could be designed to allow heavy spring flows of highly turbid water into riparian areas to regenerate cottonwood stands. This could only occur in areas that do not contain valuable spring creeks. Small pockets of cottonwoods within large stands could be cut to allow sunlight to reach the ground. Flood gates could be opened in the spring to allow flooding. Silt left behind would provide a viable site in the cut openings for seed germination and regrowth. The development of wetland areas could potentially be enhanced by planting native wetland/riparian habitat. This action would speed up the natural vegetation process.

Costs: First costs shown are Oct. '92 P.L. with Oct. '95 P.L. shown in ().

Wood Spur Dikes - would involve driving a row of wood piles near levee, attach heavy wood planks and backfill with heavy rock at $16,630 ($18,127) each.

Rock Spur Dike - would involve excavating the river bed to toe depth and fill with large rock, not backfilling the toe at $76,620 ($83,516) each.

Boulder Field Placement - would involve finding and/or blasting boulders and dumping into the river with no toe in at $3,000 ($3,270) each.

Steel Spur Dikes - would involve driving a row of H piles near the levee, attaching corrugated facing and backfilling with heavy rock at $34,570 ($37,681) each.

Relocate Root Tree (Root-Ball Revetment) Systems - would involve relocating existing root/tree systems to create temporary revetments on designated islands and maintain annually at $8,040 ($8,764) each.

Earthwork Pilot Channel (Pilot Channel Thru Existing Island) - would involve excavating new pilot channel thru existing islands to increase diversity at $64,450 ($70,250) each.

Earthwork Pilot Channel (Sediment Levees and Banks) - would involve dredge channel bottom to restore island banks and protect habitat at $28,830 ($31,425) each.

Wood Training Fence - would involve constructing a deep-set wood fence at the upstream nose of designated islands to divert flood flows and discourage erosion at $9,070 ($9,886) each.

Outputs/Benefits: The islands will provide wildlife value, such as waterfowl nesting, and the vegetated shores will provide overhanging cover for fish and will stabilize river channels. Stable river channels allow greater benthos production and associated fisheries values and reduced impingements on levees. Training fences are designed to catch debris and physically deflect about 50 percent of the incident flow. Spur dikes have the potential to replace lost pool habitat and increase the physical complexity of the shoreline. Large boulder placement provides resting pools similar in habitat quality to those provided by other means and would have a very natural appearance. Snags from the root ball placement, could be positioned at key locations to protect islands and provide fish habitat. Chains of snags could deflect flows around islands. Cottonwood snags could be tied to driven piles to build training fences. Wildlife species would benefit in floodplain habitat development by modifying contours and excavating pools for selected species.

RAPID CREEK, SOUTH DAKOTA
Omaha District

Location: Rapid Creek and its watershed are located on the eastern slope of the Black Hills in western South Dakota. The flow of Rapid Creek through Rapid City, South Dakota is partially regulated by Pactola Reservoir, which was constructed in 1956 for flood control and water supply.

Resource Problems: Rapid Creek has been extensively channelized for flood control, road and railroad construction, and urban development. Stream length, within the Rapid City urban area, has been shortened from 48 km. to 14 km. (29.76 miles to 8.68 miles) (Glover, 1979). The original width of Rapid Creek varied from nine (9) m. to 15 m. (29.52 ft. to 49.20 ft.) before the stream was channelized. Channelized width was 30 m. to 50 m. (98.40 ft. to 164 ft.). On June 9, 1972, a major flood on Rapid Creek occurred as a result of a 100-year precipitation event that was concentrated in the lower portion of the basin. Over 230 people were killed, and property damage exceeded $100,000,000. Much development in the floodplain of the creek was destroyed, and both riparian as well as aquatic habitat was decimated with consequential impacts to restoration.

Objectives: As a component of the U.S. Army Engineer District, Omaha's (CEMRO) reconstruction of flood control facilities along Rapid Creek, recreational, fisheries, and riparian habitat improvements were sought. The Corps established a greenbelt along the stream. At the request of Rapid City and the South Dakota Department of Game, Fish and Parks (SDGFP), they also began to plan and construct features to improve the trout habitat within the city limits along Rapid Creek. The specific objective of these stream restoration efforts is to create habitat capable of producing 0.5 catchable trout per angler hour.

Management Measures: Five basic features were used to rehabilitate Rapid Creek by reestablishing a natural meandering pattern and providing significant ecological enhancement. These five features are: a) riprap, b) wing deflectors, c) rock ledge pools, d) boulder clusters, and e) bank covers.

Riprap: Stone riprap was used to prevent bank erosion and reduce stream width. The stone is described as quarry stone of such quality that it will not disintegrate on exposure to water or weathering. The riprap was placed at one (1) ton per linear foot at the natural angle of repose, and the stream bed was excavated for placement of the toe of the stone 0.45 meters (1.48 feet) below the existing streambed. Gradation of the stone is as follows:

Weight	Percent
<450 lbs.	100%
>340 lbs.	60%
< 45 lbs.	10%

Wing Deflectors: The wing deflectors used in Rapid Creek are similar in function to traditional navigation dikes used to reduce channel width, concentrate flow, and provide increased depth. For the Rapid Creek Project, they were designed, with a low profile and a wide triangular shape, to simulate a natural point bar. The wing deflectors were constructed using riprap along the water deflector interface and were backfilled using material excavated from the stream bed. Wing deflectors in Rapid Creek were constructed to an elevation of no more than 0.5 meters (1.64 ft.) above the low water surface.

Topsoil was placed over the stream bed material to a depth of 15 cm. (5.85 in.) Kentucky Bluegrass (*Poa pratensis*) sod was placed on the topsoil, because the variety was readily available from commercial sources and was relatively inexpensive. Natural riparian species have subsequently replaced the sod. The sod was attached to the topsoil using two (2) to four (4) staples per sod strip with staples made from a 2.5-cm. (0.98 in.)-wide by 15-cm. (5.85 in.)-long U-shaped length of No. 11 or larger ungalvanized steel wire.

Rock Ledge Pools: Rock ledge pools were constructed by burying flat quarry stone boulders, 0.6 to 1.5 meters (1.97 ft. to 4.92 ft.) long flush with the streambed in an upstream U or V-shaped pattern, between riprap-protected banks or between two (2) wing deflectors. A pool was excavated on the downstream side of the boulders. Dimensions of the excavated pools were 1.2 to 1.5 meters (3.94 ft. to 4.92 ft.) deep, 3.5 meters (11.48 ft.) wide, and 3.5 to 4.5 meters (11.48 ft. to 14.76 ft.) long. For added cover, five (5) or six (6) stones, 0.6 to 1 meter (1.97 ft. to 3.28 ft.) in diameter, were placed in the excavation.

Boulder Clusters: Boulder clusters were used to provide cover and resting locations for trout. Clusters consisting of three (3) to five (5) large stones, 0.6 to 1.2 meters (1.97 ft. to 3.94 ft.) in diameter, were placed in the stream to deflect the current, and to cause some scour around and downstream of the stones. Location of boulder clusters was determined in the field during construction of the project to observe their effect. The boulders were thus arranged to maximize their impacts upon local velocity diversity and to ensure prevention of bank scour problems.

Bank Cover: Several bank covers, varying in length from 25 m. to 60 m. (82 ft. to 196.8 ft.), were constructed along Rapid Creek. The bank covers were constructed by driving 20-cm. to 25-cm. (7.8 in. to 9.75 in.) diameter posts into the streambed. The posts were cut off at the low water elevation and covered with concrete slabs about 1.5 meters (4.92 ft.) wide, 3.6 meters (11.81 ft.) long, and 6 cm. (2.34 in.) thick. The slabs were covered with stream bed material, then overlaid with filter fabric, topsoil and sod. Riprap was used to protect the sod along the edge of the slab, and was used beneath the slab on the stream bank to prevent excessive erosion. Bank cover structures were often used with a wing deflector or riprap on the opposite bank that forced the current beneath the cover. Bank cover structures were placed on the outer bends of the stream.

Costs: The construction costs associated with the restoration of aquatic habitat in 7.9 km. (4.9 miles) of stream were $310,000 Oct. '84 P.L. ($399,900).

Outputs/Benefits: Glover and Ford (1990) reported on extensive fish population sampling to determine the effectiveness of stream improvement measures implemented in 1979 in a section of Rapid Creek near Baken Park. Fish populations changes were very dramatic. The estimated number of brown trout per 150 meters (492 feet) of stream increased from 165 in 1978 to 712 in 1982, and the number of mountain suckers decreased from 1144 to 181 over the same period.

The stream improvements reestablished a meandering pattern with a series of pools and riffles in the previously channelized stream. A decrease in width and an increase in depth of the low-flow channel, and decreased warm season water temperatures have resulted. In general, the flood capacity has been maintained by keeping the constructed features at or only slightly above the elevation of low flow.

SIMS BAYOU, HOUSTON, TEXAS
Galveston District

Location: The Sims Bayou watershed comprises approximately 94 square miles in the southern part of Houston, Texas. Sims Bayou lies about four (4) to six (6) miles south of the downtown business district, and drains much of the urbanized portion of Houston and its surrounding communities.

Resource Problems: The authorized flood control project included the enlargement and rectification of 19.3 miles of channel in order to provide a 25-year flood protection level. The design channel was a monotypic trapezoidal channel, with expansive sections of composite and cellular concrete. Opposition to the proposed design by residents and environmental organizations was substantial. A revised design that would meet the flood protection objectives and include aesthetic, recreational, and environmental benefits was needed.

Objectives: The objective of the redesign, as stated by the project manager, was to "achieve an environmentally sensitive solution that is also affordable, not to achieve an affordable solution that minimizes environmental degradation and is ambivalent to ugliness." The redesign was obligated to achieve at least 95 percent of the original project benefits, but to include recreation and aesthetic features acceptable to residents and environmental activists.

Management Measures: The US Army Corps of Engineers Galveston District (CESWG) worked closely with all project stakeholders to ensure the redesign objectives were met. A high priority was placed on aesthetics. Critical to the success of the project was the level of cooperation, compromise, and communication with all parties undertaken by the CESWG.

Design improvements included:

- Revised channel sections that were less uniform
- Elimination of cast-in-place concrete slopes
- Reduced thickness of Cellular Concrete Mats (CCM's)
- Reduced extent of CCM's
- Open, rather than closed, CCM's to accommodate vegetation
- Addition of a second in-channel berm
- Addition of more trees
- Incorporation of trees on flood bench berm
- Adjustment of channel alignment
- Adjacent wetlands restoration
- Incorporation of a comprehensive recreational development plan

Costs: The resulting design was estimated at $23,240,000 Oct. '90 P.L. ($26,261,200).

Outputs/Benefits: The resulting design will provide an estimated $280,000,000 ($316,400,00) annual flood control benefit and $945,000 ($1,067,850) annually for recreation benefits.

SOUTH PLATTE RIVER, LITTLETON, COLORADO
Omaha District

Location: The restoration project is located on the South Platte River, immediately below Chatfield Dam in Littleton, Colorado, a southern suburb of Denver, Colorado. In the initial planning stage for this rehabilitation project, three (3) reaches were assessed for potential mitigative measures. Segment 1 is approximately 3.9 km. (2.42 miles) long and referred to as the Littleton Floodplain Park. Segment 2 had been channelized and is characterized by a trapezoidal channel with a bed width of 30 to 40 meters (98.40 ft. to 131.20 ft.), and with a 2V to 1H side slopes of graded stone riprap. Segment 2 is extremely uniform with few pool areas. Maintenance of the design channel requires removal of woody vegetation. Segment 3 is channelized with physical characteristics similar to Segment 2. Water quality diminishes from Segment 1 through Segment 3, due to urban runoff and effluent discharges from local municipal treatment facilities.

Problem: Approximately 4.3 miles of the South Platte River were channelized in 1988 to provide flood control benefits to Littleton, Colorado. The design section, a riprap-blanketed trapezoid, did not provide adequate habitat for brown trout, which, though not abundant in the project reach, were highly sought for recreational fishing. Supplement No. 1 to the Design Memorandum PC-20 called for the mitigation of aquatic habitat impacts from the channelization and, more specifically, the restoration of adequate habitat for the sustenance of brown trout.

Objectives: The purpose of the project was to compensate for fish and wildlife habitat loss caused by channelization of the South Platte River downstream from Chatfield Dam. Numerous site visits and coordination meetings with State and local agencies were conducted to ascertain the best use of available construction funds. The consensus was that an increase in fish population would have the best degree of success in the Littleton Floodplain Park reach (Segment 1). The reasons for this decision were: a) Segment 1 had the highest water quality; b) public ownership of the adjacent land in the park permitted good access during construction, provided good recreation access, and allowed a more comprehensive treatment; c) conveyance-related maintenance of woody vegetation was not required; and d) impacts of habitat structures on bankline erosion and flood profile were much less important in Segment 1 than in downstream urbanized areas.

Management Measures: The overall plan maximized the use of five types of features and was predicated on the concept that numerous small structures that take maximum advantage of existing good habitat, rather than two (2) or three (3) large structures, would be best. The five (5) types of structures used to increase pool and holding habitat, particularly during low flow conditions, are: a) rock check dams, b) two (2) types of rock deflectors, c) boulder clusters, d) three (3) types of biostabilization, and e) revetments. These five (5) types of features are described in the following sections.

Rock Check Dams: Rock check dams were constructed as low-profile structures using boulders 1 to 1.2 m. (3.28 ft. to 3.94 ft.) in diameter placed across the channel in an upstream V-shaped structure. The center of the V was depressed for recreational boat passage and marked by large boulders placed on both sides of the access. Boulders were placed on a bedding of graded riprap and extended no more than 0.5 m. (1.64 ft.) above the channel bed. A scour pool was excavated downstream from the structure and several large boulders were placed in the excavation.

Rock Deflectors: The Type 1 deflector had a shape similar to that of a typical navigation dike and was constructed of graded stone with boulders 1 to 1.2 m. (3.28 ft. to 3.94 ft.) in diameter placed along the upstream face. These deflectors extend three (3) to six (6) m. (9.84 ft. to 19.68 ft.) into the channel and vary in height from approximately 0.5 m. (1.64 ft.) above the bed at the head to bank high at the root. Stone revetment was placed upstream and downstream for a distance of 4.5 m. (14.76 ft.) to prevent erosion.

The Type 2 deflector is much larger but with lower profile than the Type 1 and has a shape similar to that of an artificial point bar. The Type 2 deflector was constructed by placing a peaked stone section around the perimeter of the structure that is backfilled with material excavated from the expected scour pool location. The upstream face was armored with boulders 1 to 1.2 m. (3.28 ft. to 3.94 ft.) in diameter embedded 0.5 m. (1.64 ft.) into the channel bottom. These features were capped with topsoil and planted with plugs of buffalo grass, switch grass, and western wheat grass on 30-cm. (11.70 in.) centers.

Boulder Clusters: Boulders of 1 to 1.2 m. (3.28 ft. to 3.94 ft.) in diameter were embedded into the stream bed. The location of each boulder was determined during construction by field inspectors. These clusters have been designed to provide rearing habitat and pool habitat adjacent to overhanging bank cover.

Biostabilization Techniques: Three (3) types of biostabilization techniques were used on the outside bank of two (2) long eroding bendways. These structures provide bank stability and overhanging vegetation cover. The upper third of each bendway was stabilized using 25 to 30 cm. (114.08 in. to 11.70 in.) diameter timber posts, approximately five (5) m. (16.40 ft.) long, driven to a depth of 2.6 m. (8.53 ft.) at a spacing of 1.8 to 2.5 m. (5.9 ft. to 8.20 ft.). Deadman soil anchors were placed every fourth pile. A semi-rigid synthetic mesh was attached to the back of the piles and to cables that had been used to connect the piles. Volunteer labor was used to backfill the structure with willow wattles and soil during the spring following construction.

The middle third of the biostabilization reach was protected using a timber bulkhead approximately 1 to 1.5 m. (3.28 ft. to 4.92 ft.) high. The remainder of the bank height was stabilized using a wattle and soil-filled bench at the top elevation of the bulkhead, with the remainder of the bank height at a 1V to 2H slope. The wall was constructed using 15 to 20 cm. (5.85 in. to 7.8 in.) diameter logs approximately 3.5 m. (11.48 ft.) in length. Deadman anchor logs, approximately 20

cm. (7.8 in.) in diameter, were spaced 1.8 m. (5.9 ft.) apart for each successive horizontal log. Riprap was used at the upstream end of the bulkhead to prevent flanking.

The lower third of the biostabilization reach was graded at 1V to 2.5H down to a bench near low-water surface elevation. The toe of the slope below the bench had been stabilized using riprap placed at 300 kg. per linear meter (1,000 lb. per linear ft.). The graded bank was seeded, and the bench was planted with willows. Due to limitations in funding, a detailed hydraulic analysis was not conducted, and a previously developed HEC-2 hydraulic analysis for the downstream channelized reach was used. At a maximum discharge of 140 cumecs (5,000 cfs), the maximum velocity was computed to be 3.43 mps (11.25 fps), with a mean of 2.4 mps (7.8 fps). Using guidelines (HQUSACE, 1991) with a safety factor of 1.75, the following stone gradation was used:

	Stone Weight (kg)	
Percent Finer	Maximum	Minimum
100	540 (1,193.4 lbs.)	180 (397.8 lbs.)
50	135 (298.35 lbs.)	90 (198.9 lbs.)
15	70 (154.7 lbs.)	30 (66.3 lbs.)

A 68-cm. (26.52 in.)-minimum stone layer with the above gradation was used for all revetments, deflectors, and hard point structures. Stones of 0.8 to 1.2 m. (2.62 ft. to 3.94 ft.) in diameter were used for rock weirs, boulder clusters, and along the upstream face of deflectors. Local scour depths adjacent to habitat structures were evaluated using Liu (1961) and Simons and Senturk (1976). Computed values varied, but the computed depths were of the same order of magnitude. Where practical, scour pockets were pre-excavated during construction.

Costs: The estimated cost for this project is $300,000 Oct. ‘90P.L. ($339,000).

Outputs/Benefits: The Colorado Division of Wildlife has monitored fish populations in the project reach since before construction. Specific data were not available for this report, but fisheries personnel report more than a ten-fold increase in the numbers of catchable brown trout as a consequence of the restoration project. Angler use of the reach has displayed a similar increase, as has other recreation including rafting, kayaking, hiking, and birding.

WILDCAT AND SAN PABLO CREEKS, CALIFORNIA
Sacramento District

Location: Wildcat and San Pablo Creeks Flood Control Project is located in Richmond, California. Both streams flow through a heavily urbanized area and periodically overflow, causing extensive flooding and sedimentation damage. Both streams originate in the coastal foothills and flow into San Pablo Bay, which is adjacent to San Francisco Bay.

Resource Problems: The resource problems for this area is the degradation of marsh pickleweed and the titmouse habitats. The San Pablo Bay marsh is environmentally sensitive. The tidally affected reach of San Pablo Creek includes a low-flow channel along the left bank, and riparian vegetation provides some cover to the low-flow water channel.

Objectives: The flood control project was originally authorized for construction by Congress in 1965, and in 1983 the project was transferred from the U.S. Army Engineer District, San Francisco to the U.S. Army Engineer District, Sacramento District (CESPK). Shortly after assuming project responsibility, CESPK issued a Design Memorandum defining the overall engineering and design for the project. Coordinating agencies and environmental groups provided extensive comments on this document regarding erosion and sedimentation aspects of the project and on the potential environmental impacts of this erosion and sedimentation on the California clapper rail and the salt marsh harvest mouse habitats. Supplementary studies, investigations, and additional coordination with interested groups resulted in a modified plan that would reduce impacts of the project construction and restore lost habitat. The objectives for this project are to restore the wetland, provide sediment control, provide flood control, and provide aesthetics.

Management Measures: Three (3) major components of this plan which are stable channel/sediment analysis, planned maintenance, and complex cross-section shape, are presented in the following paragraphs.

Sedimentation Analysis and Basin: Supplementary investigations included a stable channel analysis using regime methods, which was then verified using a numerical model (HEC-6, Scour and Deposition in Rivers and Reservoirs) developed by USACE. A sedimentation basin was designed and constructed on Wildcat Creek to prevent the sediment from entering sensitive marsh areas.

Cross-Section Shape: Another major feature of the revised plan was a complex cross-section shape for the project. The complex shape includes: low flow channel, grass vegetated floodway, planting strip along one bank, and planting benches along one or both sides. This widened, vegetated cross section was designed to mitigate lost riparian habitat due to project construction and to capture coarse sediments in the overbank areas. In addition, a widened, flat-sloped transition area was designed to trap sediment at the interface of the sensitive marsh area and the upper reaches of the creek (Sing, 1988).

Maintenance: Contra Costa County Flood Control and Water Conservation District is responsible for the long-term maintenance of the channel conveyance. Rather than establish a regular mowing, spraying, or cutting schedule that would negate the careful preservation of riparian habitat and extensive landscaping, specific cross sections are monitored annually in the spring of the year after the flood season. The amount of sediment removal, vegetation and debris clearing is determined during the annual monitoring. Cross section monitoring and evaluation consists of the following steps:

a) Survey each cross section and compare to the as-built cross-section geometry.

b) Photograph each cross section and determine the effective hydraulic roughness by comparing the existing vegetation to pictorials provided to the county by CESPK.

c) Use the determined Manning's n value and the net area of deposition in a backwater model to determine the percentage loss or reduction in freeboard for each cross section. A freeboard loss of 50 percent or greater requires uniform maintenance of the entire representative reach.

d) If one section within a reach indicates that maintenance is necessary while another indicates that no maintenance is needed, then maintenance is undertaken on a selective basis where required.

e) Report the findings of the channel monitoring on a reach-by-reach basis in semiannual reports, and provide for maintenance if needed. These reports are reviewed by CESPK.

Although this monitoring program required considerable effort to formulate and to manage, the program permits reasonable development of riparian vegetation and minimal maintenance expense.

Costs: The estimated project cost was $28,800 Oct. '89 P.L. ($33,408).

Outputs/Benefits: This project has provided flood control benefits (unspecified benefits), but the restoration efforts have fallen short of expectations, because of failure of early vegetation plantings and poor maintenance.

CHAPTER VI - BENEFICIAL USES OF DREDGED MATERIAL PROJECTS

The following are five (5) examples of Corps projects that demonstrate beneficial uses of dredged material. The format of these projects will be somewhat different than the projects discussed previously.

BOLIVAR PENINSULA MARSH CREATION SITE
Galveston District

Project Location: The project is located on Goat Island, Galveston Bay, Texas**.**

Project Type: The project is a salt marsh creation which used a previously-placed dredged material deposit.

Project Size: The old Bolivar site is 10 acres, the new Bolivar is 10 acres, the control Bolivar site is 10 acres, and three (3) natural reference sites are of varying sizes.

Energy Sources: There is a twenty-six (26) mile northerly wind fetch across Galveston Bay.

Protection Provided: A temporary structure made of 10 x 4-foot sandbags filled with fine grain sand dredged material to form a dike at the old Bolivar site was constructed in 1975 and a floating tire breakwater, plant rolls, and a erosion control mat were constructed at new Bolivar site in the 1980's.

Vegetation Used: Smooth cordgrass in the low marsh zone and saltmeadow cordgrass in the high marsh zone were planted behind temporary breakwaters, although several minor upland plant species were tested in the upper zone at the old Bolivar site in the 1970's. Considerable natural colonization occurred, especially in the high marsh and upland areas.

Project Constructed: The first dredged material was placed in the 1960's. The marsh project on old Bolivar initiated in 1975 and the marsh project on new Bolivar initiated in 1980.

Monitoring: Monitoring has occurred since 1974 on old Bolivar. Old Bolivar was compared to three (3) natural reference marshes. Monitoring initiated on new Bolivar and control Bolivar (where no planting occurred), in 1980 (six (6) sites in all).

Success or Failure: The short-term success of the marsh is good and the long-term success is looking adequate; but the areas are still being monitored.

Costs: The costs of this project is less than $1 ($1.57) Oct. ‘80 P.L. per cubic yard of dredge material and was approximately $2,500 ($3,925) per acre to plant, and the geotextile dike was an additional expense.

GAILLARD ISLAND CONFINED DISPOSAL FACILITY
Mobile District

Project Location: The project is located two (2) miles out in the Bay from Theodore, Alabama.

Project Type: The project is a confined disposal facility built of dredged material located in Mobile Bay. The marsh was planted along the northwest dike.

Project Size: The confined disposal facility is a triangular-shaped island, 1,300 acres in size; the planted marsh, which is a demonstration project, is 35 acres.

Substrate Type: The substrate type of this area is of a silty sand dredged material.

Energy Sources: Wave and wind energies buffer all three (3) sides of the island, with long wind fetches and with ship/barge wakes hitting the south and east dikes.

Protection Provided: The east and part of the south dikes were riprapped; planting occurred behind floating tire breakwaters on the northwest dike, using plant rolls and erosion control matting.

Vegetation Used: Smooth cordgrass was planted. Natural colonization behind berms which formed from trapped sediments, included saltmeadow cordgrass, saltmarsh bulrush, saltmarsh cattail, American three-square, and a number of other minor species in the marsh zones. The upland was aerially seeded with grasses, then planted with a variety of both exotic and native tree species (only native species survived).

Project Constructed: The island was built between 1980-81.

Monitoring: Monitoring for this project began in 1981. The island was created over bay bottom, but no baseline data were collected on fishes or benthos and seagrasses were not present. Island monitoring included vegetation, wildlife, some fisheries, and physical changes. Seabird use of the island has been spectacular, with thousands of pairs of over 20 species of terns, gulls, skimmers, pelicans, stilts, and others nesting on the island in increasing numbers since its construction. Wading birds began occupying the island in 1988, when vegetation reached successional stages that would support their nests.

Success or Failure: Short-term: success of planted marsh mixed, success of colonized marsh is very high, success of wildlife use of island habitats is excellent.

Costs: Approximately $1.25 Oct. ‘80 P.L. ($1.96) per cubic yard; confined disposal facility was constructed to have life expectancy of approximately 40 years.

JETTY ISLAND SALT MARSH/SEAGRASSES CREATION SITE
Seattle District

Project Location: The project is located in Port Gardener Bay; adjacent to the Shohomish River navigation channel in Puget Sound, at Everett Harbor, Washington.

Project Type: The project comprises of an island, marsh, and seagrass habitat development which used maintenance dredged material.

Project Size: The project is over 100 acres.

Substrate Type: The substrate type in this project area is made up of sand dredged material.

Energy Sources: Energy sources include a several mile westerly wind fetch, eight (8) + foot tides, river currents, and current movement within Puget Sound.

Protection Provided: The project would include a sandy berm structure on the main energy side and a rock jetty on the channel side for training the river currents.

Vegetation Used: The original island had natural colonization of vegetation, the new intertidal marsh, mudflat, and upland was planted with tufted hairgrass, slough sedge, dune grasses, eelgrass, and other species from an adjacent donor site and nursery stock.

Project Constructed: Initial rock jetty was constructed in 1903 and the island resulted from frequent maintenance dredging with unconfined disposal of dredged material. An environmentally engineered protective berm and intertidal saltmarsh was constructed in 1989.

Monitoring: Intensive monitoring was conducted during the 1980's. Low-level observations and data was collected until 1985, then intensive monitoring again prior to berm construction and marsh planting. A detailed monitoring plan agreed upon by the interagency working group, and is being carried out by Seattle District and Port of Everett. A five (5) year evaluation report on the project was completed in April 1996.

Success or Failure: The has shown to be a highly successful site. The island upland is being used for day visits with park rangers and nature tours. The first Arctic tern nests in contiguous states has been sited on Jetty Island along with much wildlife use. New marsh and seagrass bed sites are thriving as well as natural colonization has occurred with additional species. The long-term monitoring program will continue. Nourishment of the protective berm is being coordinated and expansion of the site is being considered.

Costs: Total Corps of Engineers O&M dredging construction cost was $620,260 Oct. ’89 P.L. ($719,502) which included placement of 323,000 cubic yards of dredged material to construct a 1,700 foot long protective berm for creation of the intertidal saltmarsh.

SALT POND #3 MARSH RESTORATION SITE
San Francisco District

Project Location: This project is located south of Hayward, California, in South San Francisco Bay, at the mouth of the Alameda Creek Flood Control Channel.

Project Type: This project comprises of a salt marsh restoration and salt pond rehabilitation which used dredged material.

Project Size: The project is approximately 100 acres.

Substrate Type: The substrate type in this area is made up of a clayey fine-grained dredged material.

Energy Sources: Energy sources include a long fierce northwesterly wind fetch across the Bay, and four (4) to five (5) foot tides.

Protection Provided: The project consisted of breaching the existing dike at site to provide intertidal flow to the marsh.

Vegetation Used: The vegetation consisted of pacific cordgrass and two (2) species of pickleweed.

Project Constructed: The salt pond has been in existence for decades, where the marsh project was carried out between 1973-1976.

Monitoring: The initial monitoring plan was under local contract which included only vegetation and birds. Long-term monitoring by WES included soils, vegetation, wildlife, physical changes (no fisheries or benthos), and is still on-going. Although less than 10 acres of the site was planted, the entire site colonized in pickleweed. Succession has been rapid, and the site now resembles older typical salt marshes of the Bay -- it no longer supports Pacific cordgrass, but is almost entirely pickleweed. The nearby flood control channel has silted in, and has colonized with cordgrass.

Success or Failure: Successful, although some people think part of the site is too high to be a good marsh because intertidal flow does not often reach the upper one-third of the site. (Due to poor construction management, dredged material was not spread evenly.)

Costs: $1.68 Sep. ‘75 P.L. ($4.03) per cubic yard including material transport, site preparation, and planting.

WINDMILL POINT MARSH CREATION SITE
Norfolk District

Project Location: The project site is located at Windmill Point in the James River, east of Hopewell, Virginia.

Project Type: The project is comprised of fresh intertidal marsh creation which used maintenance dredged material.

Project Size: The project is approximately fifteen (15) acres.

Substrate Type: The substrate in the project area is made up of both sand dredged from a borrow area and silt maintenance dredged material.

Energy Sources: The energy sources are of a strong river and flood currents, three (3) foot tides, and several miles of wind fetch from the west.

Protection Provided: The project is a temporary sand dike which serves as a breakwater.

Vegetation Used: The vegetation on the dike is made up grasses and forbs. In the island interior, natural colonization occurred before site could be planted.

Project Constructed: The marsh was designed and built by USACE in 1974.

Monitoring: Pre-, during, and post-construction monitoring was conducted by the Waterways Experiment Station and its contractors which include: University of Virginia, Virginia Military Institute, Old Dominion University, Environmental Concern Inc., and others.

Success or Failure: The island broke in half when the sand dike failed, and the interior marsh mostly washed out in 1983. It has been successful as a protected shallow water habitat for fish spawning and use by wildlife on the remnant island. But as a stable marsh, it was a failure. Many lessons have been learned in the early effort.

Costs: The cost for this project was approximately $1.00 Oct. ‘74 P.L. ($2.74) per cubic yard for construction.

CHAPTER VII - UNIT PRICING OF ENGINEERING FEATURES

The information in the following tables was derived from the Microcomputer Aided Cost Engineering System (MCACES) sections from several of the studies discussed in this report. Not all the studies received, contained detailed cost estimates or had an attached MCACES section. All of the unit pricing has been updated to the October 1995 Price Level using the Civil Works Construction Cost Index System - EM 1110-2-1304, August 1996. The unit price for each engineering feature includes estimates for labor, equipment, supplies, and materials.

In the following tables (Tables 10-24), there are 15 main headings (e.g., Combination of Structural and Non-Structural Elements). Within each of these main headings are indexed the studies (e.g., Homme Lake) from this report and the state (ND) in which each of the studies are located, as well as the location in the report (page number) in which the study was previously described. Under these main headings are lists of various engineering features (e.g., Artificial Nesting Structures, Waterfowl Pair Ponds, and Use of Standpipe Culvert for Water Level Manipulation). Each engineering feature includes the item/components which supports each feature (e.g., Excavation/Backfill for Culverts). Each item/component will have unit of measure, quantity, unit price, and the percent contingency.

Several item/components are reiterated within the different engineering features. Examples of this are mobilization, demobilization, and preparatory work, seeding, excavation, dewatering, and riprap. These type of item/components are basic elements within many engineering features.

The quantities for each item/component in the tables provide readers a perception whether or not the more one purchases, the cheaper the unit price. In a few instances, this was the case; but in most, the unit price remained the same. The contingencies shown were taken directly from the studies. The contingencies were incorporated, in most cases, after the total construction cost was calculated.

Readers can refer to the Table of Contents, List of Tables (pages viii - xi) for a quick reference for the location of specific engineering features in Tables 10 - 24.

TABLE 10
COMBINATION OF STRUCTURAL AND NON-STRUCTURAL ELEMENTS

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
ARTIFICIAL NESTING STRUCTURES, WATERFOWL PAIR PONDS, USE OF STANDPIPE CULVERT FOR WATER LEVEL MANIPULATION					
ND	**Homme Lake - pg. 34**				
	Mob, Demob, & Prep. Work	LS	1	4,072.00	13.90
	48" Diameter Culverts	EA	7	236.62	26.70
	Excavation/Backfill for Culverts	CY	435	3.16	25.00
	Blasting	EA	4	1,562.00	35.70
	Mob, Demob, & Prep. Work for Control Standpipe	LS	1	141.00	100.00
	Control Structure (Control Standpipe)	LS	1	1,127.80	30.00
	36" C.S.P.	LF	36	61.39	15.00
	72" x 96" Anti-Seep Diaphragm	EA	1	498.00	25.00
	Road Removal/Replacement	LS	1	1,210.00	100.00
AT-GRADE CONTROL STRUCTURES					
NV	**Lower Truckee River - pg. 43**				
	Steel Sheet Metal Piling driven 20 feet below stream bed.	SF	9,200	46.26	25.00
BOAT PASSAGE STRUCTURE					
IL	**Stump Lake - pg. 103**				
	Dewatering (2)	LS	1	127,125.00	35.00
	Concrete Reinforcement	CY	42	169.50	30.00
	Bedding Stone, 3" minus	TN	540	24.86	20.00
	Excavation	CY	1,400	1.70	20.00
	Clearing and Grubbing	AC	0.8	2,034.00	20.00
	Seeding	AC	0.4	1,356.00	20.00
	Riprap 12"	TN	20	16.95	20.00
	Embankment	CY	400	2.83	20.00
	Gantry Crane w/Chain Hoist	EA	2	881.40	20.00
	Geogrid	SY	750	11.30	20.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
BOULDER FILLED PLACEMENT					
WY	**Jackson Hole - pg. 144**				
	Earthwork for Structures	EA	6	545.00	30.00
CATTLE GRAZING TECHNIQUES					
NV	**Lower Truckee River - pg. 43**				
	5 Strand Barbed Wire Fencing	LF	89,000	2.80	25.00
	Water Wells with Tank, Trough and Solar Operated Pumping Wells to be placed near river; assume average pumping depth = 50 feet. Wells	EA	16	10,080.00	25.00
	Tank	EA	16	2,240.00	25.00
	Troughs	EA	16	1,120.00	25.00
	Distribution Line	LF	20,000	5.60	25.00
	Sterilize wells/test	EA	16	2,240.00	25.00
CHECK DAMS					
NV	**Lower Truckee River - pg. 43**				
	Mob. & Demob.	LS	1	2,800.00	25.00
	Dredged Material	CY	400	11.20	25.00
	Waterproofing membrane	SY	540	2.80	25.00
CONTROL BEAVER POPULATION					
NV	**Lower Truckee River - pg. 43**				
	Control Beaver Population (mi/yr)	LS	1	823.00	25.00
DEFLECTOR STRUCTURE (FENCE)					
NV	**Lower Truckee River - pg. 43**				
	Wooden Fence - 5" diameter peeler core posts - 4' length; 2x6 braces - 8' length.	LF	500	11.20	25.00
ENHANCE PALUSTRINE HABITAT					
NV	**Lower Truckee River - pg. 43**				
	Upstream Rock Weir - 9 acres.	EA	3 oxbow sites	103,000.00	25.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
ERADICATE TAMARISK TREES					
NV	**Lower Truckee River - pg. 43**				
	Clearing and Grubbing	AC	1	3,360.00	13.00
	Soil Poisoning	JB	1	3,360.00	13.00
	Reestablish vegetation	AC	1	7,840.00	13.00
IL	**FORESTED WETLAND MANAGEMENT AREA - STOPLOG STRUCTURES**				
	Peoria Lake - pg. 87				
	Dewatering	LS	1	15,525.00	15.00
	Excavation	CY	825	4.37	10.00
	Structural Backfill	CY	627	13.80	15.00
	Structural Concrete	CY	198	437.00	15.00
	Grating	SF	828	40.02	20.00
	Steel Guardrail	LF	264	37.66	20.00
	Stop logs, wood	LF	720	43.31	20.00
	Riprap	TN	360	30.36	15.00
HEMI MARSH STOP LOG STRUCTURE					
IL	**Spring Lake - pg. 98**				
	Dewatering	LS	1	14,279.00	30.00
	Excavation	CY	830	3.60	10.00
	Structural Backfill	CY	400	14.28	20.00
	Structural Concrete	CY	65	507.00	25.00
	Stop Logs	LS	1	2,322.00	25.00
	Heavy Duty Grating	SF	81	69.38	15.00
	Guard Rail	LF	82	58.00	15.00
	Staff Gage	EA	1	654.00	15.00
HILLSIDE SEDIMENT CONTROL STRUCTURES					
IL	**Swan Lake - pg. 106**				
	Ponds	EA	55	8,402.00	0.00
	Terraces	EA	40	2,800.00	0.00
	Basins	EA	95	2,798.00	0.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
INTERGRAVEL ENVIRONMENT					
NV	**Lower Truckee River - pg. 43**				
	Intergravel Environment	SF	44,000	22,000.00	25.00
ISLAND CONSTRUCTION					
IL	**Swan Lake - pg. 106**				
	Excavation	CY	15,900 to 25,350	6.48	20.00
	Seeding	AC	7	1,711.00	17.00
	Hay Bails	LF	11,100 to 30,600	0.95	13.00
LAKE STOP LOG STRUCTURE					
IL	**Spring Lake - pg. 98**				
	Dewatering	LS	1	18,857.00	30.00
	Excavation	CY	650	3.65	10.00
	Structural Backfill	CY	300	14.82	20.00
	Structural Concrete	CY	56	506.85	25.00
	Stop Logs	LS	1	1,700.00	25.00
	Heavy Duty Grating	SF	81	69.38	15.00
	Guard Rail	LF	82	58.00	15.00
	Staff Gage	EA	1	654.00	15.00
IL	**Spring Lake - pg. 98**				
	Dewatering	LS	1	14,279.00	30.00
	Excavation	CY	830	3.60	10.00
	Structural Backfill	CY	400	14.28	20.00
	Structural Concrete	CY	65	507.00	25.00
	Stop Logs	LS	1	2,322.00	25.00
	Heavy Duty Grating	SF	81	69.38	15.00
	Guard Rail	LF	82	58.00	15.00
	Staff Gage	EA	1	654.00	15.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
	LANDSCAPING				
IL	**Potters Marsh - pg. 95**				
	Seeding, Dike & Perimeter Area	AC	10.5	1,665.00	15.00
	Seeding, Interior Grassland	AC	7	1443.00	15.00
	LAKE EXCAVATION				
IL	**Lake Chautauqua - pg. 83**				
	Lake Excavation	CY	29,500	4.26	25.00
	LOGS SILLS, QUARRY SPALLS & VEGETATION				
WA	**Sammamish River, Site #1 - pg. 56**				
	Mob, Demob, & Prep. Work	LS	1	2,120.00	20.00
	Excavation	CY	550	8.48	20.00
	Planting (Trees & Shrubs)	LS	1	15,900.00	20.00
	Quarry Spalls	TN	20	31.80	20.00
	Bridge	LS	1	53,000.00	20.00
	Log Sills	EA	2	2,915.00	20.00
WA	**Sammamish River, Site #2 - pg. 56**				
	Mob, Demob, & Prep. Work	LS	1	1,590.00	20.00
	Excavation	CY	5,100	8.48	20.00
	Planting (Trees & Shrubs)	LS	1	14,840.00	20.00
	Quarry Spalls	TN	80	31.80	20.0
	Log Sills	EA	2	2,650.00	20.00
	Log/Rootwad Fish Habitat	EA	30	265.00	20.0
WA	**Sammamish River, Site #3 - pg. 56**				
	Mob, Demob., Prep. Work	LS	1	1,590.00	20.00
	Excavation	CY	5,400	8.48	20.00
	Planting (Trees & Shrubs)	LS	1	14,840.00	20.00
	Low Flow Deflectors Quarry Spalls	TN	300	31.80	20.00
	Log/Rootwad Fish Habitat	EA	52	265.00	20.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
	NEW WELLS				
IL	**Potters Marsh - pg. 95**				
	Drill Well, Casting and Well Screen	LS	1	24,198.00	100.00
	Submersible 5 HP Pump	EA	1	2,509.00	100.00
	Electrical Feed and Platform	LS	1	62,049.00	20.00
IL	**Spring Lake - pg. 98**				
	New Well	LS	1	52,102.00	35.00
	Electrical Power	LS	1	34,989.00	35.00
	OVERFLOW AREAS				
IL	**Spring Lake - pg. 98**				
	Riprap	CY	667	49.32	20.00
	PILOT CHANNEL EXCAVATION				
WY	**Jackson Hole - pg. 144**				
	Mob., Demob., & Prep. Work	LS	1	10,900.00	30.00
	Care and Diversion of Water	LS	1	2,725.00	30.00
	Pilot Channel Excavation, Width - 100'; Length - 300'	CY	3,711	15.26	30.00
	POTHOLES				
IL	**Potters Marsh - pg. 95**				
	Mechanically Excavated	EA	16	6,382.00	20.00
	Blasted Holes	EA	7	17,094.00	25.00
	RIPRAP - STRUCTURAL BANK PROTECTION				
NV	**Lower Truckee River - pg. 43**				
	Excavation (to waste)	CY	4,000	1.68	25.00
	Imported Fill	CY	14,800	2.91	25.00
	Filter Cloth	SY	25,800	5.60	25.00
	Riprap	TN	27,600	20.16	25.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
ROCK JETTIES OR BREAKWATER					
NV	**Lower Truckee River - pg. 43**				
	Rock Jetties or Breakwater	Mile	1	2,200,000	25.00
ROCK SPUR DIKE					
WY	**Jackson Hole - pg. 144**				
	Mob., Demob., & Prep. Work	LS	1	10,900.00	30.00
	Care and Diversion of Water	LS	1	2,725.00	30.00
	Excavation	CY	3,184	5.45	30.00
	Rock Fill	CY	1,071	49.05	30.00
ROOT-TREE RELOCATION					
WY	**Jackson Hole - pg. 144**				
	Mob., Demob., & Prep. Work	LS	1	545.00	30.00
	Care and Diversion of Water	LS	1	109.00	30.00
	Remove Root System	EA	28	54.50	30.00
	Cut to Length	EA	28	32.70	30.00
	Haul to Site	EA	28	109.00	30.00
	Dig Trench	CY	154	5.45	30.00
	Place Root System	EA	28	54.50	30.00
	Backfill	CY	77	3.27	30.00
SHORELINE AND BANKLINE PROTECTION (VEGETATIVE)					
IL	**Swan Lake - pg. 106**				
	Willow Wattlings	LF	2,700	6.15	23.00
	Willow Cuttings	SF	15,200	0.24	23.00
IL	**Swan Lake - pg. 106**				
	Willow Wattlings	LF	4,700	6.15	23.00
	Willow Cuttings	SF	26,700	0.24	23.00
IL	**Swan Lake - pg. 106**				
	Willow Cuttings	SF	205,000	0.24	23.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
SIDE CHANNEL EXCAVATION					
IL	**Lake Chautauqua - pg. 83**				
	Mob. & Demob.	LS	1	89,824.00	10.00
	Clearing & Grubbing	AC	16.9	2,027.00	20.00
	Excavation	CY	195,900	2.13	15.00
	Rockfill	TN	800	33.43	15.00
	Riprap	TN	5,700	37.74	15.00
	Seeding	AC	19	1,288.00	20.00
SIDE CHANNEL RESTORATION					
IL	**Peoria Lake - pg. 87**				
	Mob., Demob., & Prep. Work	LS	1	17,767.00	10.00
	Clearing and Grubbing	AC	11	2,702.00	15.00
	Excavation/Bckt. Slope Shaping	CY	104,000	2.88	15.00
	Rockfill	TN	1,200	27.89	15.00
	Seeding	AC	24	1,472.00	15.00
	Woody Cuttings	EA	15,000	1.15	15.00
	Tree Seedlings	EA	250	12.77	15.00
	Turbidity Curtain, Anchors	EA	36	266.80	20.00
	Turbidity Curtain Skirt. & Hndlg.	LF	1,600	24.44	20.00
	Rock Substrate	TN	3,600	27.89	15.00
STEEL SPUR SPIKES					
WY	**Jackson Hole - pg. 144**				
	Mob., Demob., & Prep. Work	LS	1	10,900.00	25.00
	Care and Diversion of Water	LS	1	2.725.00	25.00
	Steel H Piles	K Lbs.	7.14	1,090.00	25.00
	Cross Bracing	K Lbs.	0.63	2,725.00	25.00
	Corrugated Sheet Steel	K Lbs.	2.70	2,725.00	25.00
	Installation	LF	960	5.45	25.00
	Rock Fill	CY	36.08	54.50	25.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
TRAINING FENCE					
WY	**Jackson Hole - pg. 144**				
	Mob., Demob., & Prep. Work	LS	1	545.00	30.00
	Care and Diversion of Water	LS	1	272.50	30.00
	Fence Posts: Wood	EA	29	13.08	30.00
	Fence Posts: Steel Pipe	FT	174	3.27	30.00
	Planks	LF	1,300	2.73	30.00
	Installation	LF	250	18.31	30.00
TRANSVERSE FENCING WITH EARTHEN CHANNEL					
NV	**Lower Truckee River - pg. 43**				
	Wood Posts - 4"x4"x6"	EA	150	17.92	25.00
	Metal - 6 feet	EA	17	35.84	25.00
	#9 Line Wire	LF	2,000	0.28	25.00
	1/2x36" AV Netting	LF	1,000	0.84	25.00
	Excavation for Pilot Channel	CY	48,400	1.68	25.00
TRANSVERSE FENCING WITH CONCRETE PILOT CHANNEL					
NV	**Lower Truckee River - pg. 43**				
	Transverse Fencing from above estimate	LF	26,500	4.70	25.00
	Excavation for Pilot Channel	CY	34,200	1.68	25.00
	Concrete Lined Channel and Training Levees Filter Cloth	SY	7,700	2.24	25.00
	Excavation	CY	43,000	1.68	25.00
	Embankment	CY	30,400	2.35	25.00
	Riprap	TN	6,200	20.16	25.00
	Concrete	CY	1,730	201.60	25.00
	Reinforcement	LB	207,800	0.56	25.00
	Cement	CWT	8,100	5.60	25.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
	TREE PLANTINGS				
MO	**Bay Island - pg. 69**				
	Hypo-hatchet Treatment	AC	20	580.00	10.00
	Acorns	AC	3	203.00	10.00
	Seedlings	AC	23	290.00	10.00
	Balled and Burlapped	AC	4	5,800.00	10.00
	Fertilize/Preparation	AC	20	116.00	10.00
	VEGETATION				
NV	**Lower Truckee River - pg. 43**				
	Restore Upland Vegetation by Clearing, Burning, Herbicide, Reseeding, and Replanting	AC	1	16,500.00	25.00
	Plant Riparian Vegetation @ 500 Plants per Acre	AC	1	7,700.00	25.00
	WOOD PILING SPUR DIKE				
WY	**Jackson Hole - pg. 144**				
	Mob., Demob., & Prep. Work	LS	1	10,900.00	30.00
	Care and Diversion of Water	LS	1	2,750.00	30.00
	Wood Piles (in place)	LF	170	54.50	30.00
	Wood Plank	BF	90	2.73	30.00
	Installation	LF	720	5.45	30.00
	Earthwork/Rock Fill	CY	36.1	54.50	30.00

TABLE 11
LEVEES

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
CONSTRUCTING PONDS BY BUILDING LEVEES AND DITCHES WITH DRAINAGE CULVERTS AND CLOSURE GATES					
OR	**Fern Ridge Lake - pg. 25**				
	Mob, Demob, & Prep. Work	LS	1	10,927.00	15.00
	Common Excavation	CY	32,000	1.74	15.00
	Levee Embankment	CY	25,000	1.33	15.00
	Spillway Rock	CY	470	22.67	15.00
	24" Diameter CMP	LF	240	26.99	15.00
	24" Diameter Sluice Gates	EA	9	335.00	15.00
	42" Diameter CMP	LF	75	87.61	15.00
	42" Diameter Sluice Gates	EA	1	1,109.00	15.00
	42" CMP Backfill	LS	1	20,748.00	15.00
	Irrigation Pump	EA	1	4,119.00	15.00
	8" Plastic Pipe	LF	1,350	19.52	15.00
	Treated Timber Posts (6'x6'x14')	EA	4	133.22	15.00
	Treated Timber Posts (6'x6'x6')	EA	16	57.06	15.00
	Electrical, Pump Hook-up	EA	1	8,680.00	15.00
DEFLECTION LEVEE					
IA	**Brown's Lake - pg. 72**				
	Clearing	AC	7	2,520.00	15.00
	Stripping	CY	5,300	2.52	15.00
	Embankment Fill	CY	50,200	5.04	15.00
	Riprap	TN	5,600	32.76	15.00
	Seeding	AC	7	1,890	15.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
	EARTHEN LEVEE				
IL	**Swan Lake - pg. 106**				
	Semi-compacted Embankment (1 on 3)	CY	64,800	4.94	20.00
	Excavation (1 on 4)	CY	195,000	6.48	20.00
	Clearing	AC	90	2,109.00	13.00
	Crushed Stone	TN	12,000	16.68	13.00
	“C” Stone	TN	10,550	21.66	13.00
	“B” Stone	TN	5,840	21.66	13.00
	CMP - 18" Diameter	LF	70	29.92	13.00
	CMP End Section - 18"	EA	2	296.22	13.00
	Crushed Stone - 1" minus	TN	7	16.32	13.00
	Asphaltic Concrete	TN	13	72.79	17.00
	Aggregate Base Course - 8"	TN	34	16.68	13.00
	Barricade - 10'	EA	2	354.66	17.00
	Access Gate - 14'	EA	2	3,399.00	13.00
	Stripping (Borrow Area)	CY	8,365	2.86	13.00
	Clearing (Borrow Area)	AC	3	2,021.00	13.00
	Seeding (Borrow Area)	AC	3	1,727.00	17.00
	Hay Bails	LF	30,600	0.95	13.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
FORESTED WETLAND MANAGEMENT AREA LEVEE					
IL	**Peoria Lake - pg. 87**				
	Mob., Demob., & Prep. Work	LS	1	21,660.00	10.00
	Road Surfacing	TN	2,750	23.46	15.00
	Clearing and Grubbing	AC	41	2,702	15.00
	Excavation/Stripping	CY	13,600	1.96	10.00
	Embankment for cell	CY	21,000	4.49	15.00
	Embankment for cells	CY	35,000	5.00	15.00
	Seeding	AC	41	1,311.00	15.00
	8" Non-perforated Drain Pipe	LF	530	7.25	20.00
	Tree Seedlings	EA	1,110	12.77	15.00
HEMI MARSH LEVEE CONSTRUCTION					
IL	**Spring Lake - pg. 98**				
	Unsuitable Soil Excavation	CY	4,150	3.38	15.00
	Embankment Fill, Place & Shape	CY	10,000	5.45	15.00
	Seeding	AC	5	2,125.59	10.00
	Crushed Stone	CY	1,200	27.90	20.00
INTERMEDIATE (INTERIOR) LEVEE					
MO	**Bay Island - pg. 69**				
	Clearing and Grubbing	AC	17	2,668.00	10.00
	Embankment Fill	CY	10,200	4.06	10.00
	Seeding	AC	17	1,392.00	10.00
IL	**Stump Lake - pg. 103**				
	Mob., Demob., & Prep. Work	LS	1	81,360.00	10.00
	Embankment	CY	1,928	2.83	15.00
	Clearing	AC	2.70	2,034.00	20.00
	Seeding	AC	1.30	1,356.00	20.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
INTERMEDIATE (INTERIOR) LEVEE, CONT.					
IL	**Stump Lake - pg. 103**				
	Embankment	CY	7,189	2.83	15.00
	Clearing	AC	8.20	2,034.00	20.00
	Seeding	AC	3.20	1,356.00	20.00
IL	**Stump Lake - pg. 103**				
	Embankment	CY	2,450	2.83	15.00
	Clearing	AC	2.90	2,034.00	20.00
	Seeding	AC	1.20	1,356.00	20.00
IL	**Stump Lake - pg. 103**				
	Embankment	CY	226	2.83	15.00
	Clearing	AC	0.50	2,034.00	20.00
	Seeding	AC	0.20	1,356.00	20.00
IL	**Stump Lake - pg. 103**				
	Embankment	CY	552	2.83	15.00
	Clearing	AC	0.70	2,034.00	20.00
	Seeding	AC	0.30	1,356.00	20.00
IL	**Stump Lake - pg. 103**				
	Embankment	CY	1,070	2.83	15.00
	Clearing	AC	2.20	2,034.00	20.00
	Seeding	AC	0.80	1,356.00	20.00
IL	**Stump Lake - pg. 103**				
	Embankment	CY	2,170	2.83	15.00
	Clearing	AC	2.40	2,034.00	20.00
	Seeding	AC	0.90	1,356.00	20.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
LAKE INTERIOR LEVEE CONSTRUCTION					
IL	**Spring Lake - pg. 98**				
	Unsuitable Soil Excavation	CY	6,000	5.07	25.00
	Embankment Fill, Place & Shape	CY	75,700	5.45	25.00
	Seeding	AC	2.5	2,125.50	20.00
	Crushed Stone	CY	1,050	27.90	20.00
	Disassemble/Assemble Floating Plant	LS	1	4,905.00	20.00
PERIMETER (EXTERIOR) LEVEE					
MO	**Bay Island - pg. 69**				
	Mob, Demob and Prep. Work	LS	1	11,600.00	35.00
	Clearing and Grubbing	AC	37	2,668.00	10.00
	Embankment Fill	CY	55,000	4.06	10.00
	Seeding	AC	37	1,392.00	10.00
IL	**Stump Lake - pg. 103**				
	Embankment Fill	CY	125,500	2.83	15.00
	Clearing and Grubbing	AC	79	2,034.00	20.00
	Seeding	AC	41	1,356.00	20.00
	Graded Stone	TN	2,100	11.30	15.00
	Quarry-run Stone (6" minus)	TN	1,900	16.95	15.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
	RAISING INTERIOR LEVEES AND PLACEMENT OF CULVERTS AND WEIRS				
IL	**Carlyle Lake - Pool 2 Lower Main Pump Ditch Alteration - pg. 21**				
	Mob., Demob, and Prep. Work	LS	1	2,398.00	15.00
	Embankment	CY	33,800	2.67	15.00
	Excavation	CY	7,870	1.64	15.00
	Seeding	AC	12	872.00	15.00
	Clearing	AC	24	545.00	18.00
	24" Dia. Gravity Drains	LF	40	38.15	15.00
	36" Dia. Gravity Drains	LF	228	54.50	15.00
	24" Gate	EA	1	2,725.00	15.00
	36" Gate	EA	6	3,270.00	15.00
	Foundation Material	TN	44	23.98	15.00
	24" Dia. Culvert Removal	LF	210	19.08	15.00
	36" Dia. Culvert Removal	LF	30	23.44	15.00
	Geoweb GW 8-4 (for 6 Weirs)	SY	2,610	10.90	15.00
	Stone 1" minus (for 6 Weirs)	TN	785	23.98	15.00
	Staff Gage	EA	10	545.00	20.00
IL	**Carlyle Lake - Pool 2A Alterations - pg. 21**				
	Mob, Demob., & Prep. Work	LS	1	1,635.00	15.00
	Embankment	CY	13,140	2.67	15.00
	Excavation	CY	590	1.64	15.00
	Seeding	AC	7	872.00	15.00
	Clearing	AC	13	545.00	18.00
	24" Dia. Culvert Removal	LF	60	19.08	15.00
	Geoweb GW 8-4 (for 1 Weir)	SY	390	10.90	15.00
	Stone 1" minus (for 1 Weir)	TN	120	23.98	15.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
	RAISING INTERIOR LEVEES AND PLACEMENT OF CULVERTS AND WEIRS, CONT.				
IL	**Carlyle Lake - Pool 1 Alterations - pg. 21**				
	Mob, Demob, & Prep. Work	LS	1	2,398.00	15.00
	Embankment	CY	37,580	2.67	15.00
	Excavation	CY	6,940	1.64	15.00
	Seeding	AC	28	872.00	15.00
	Clearing	AC	53	545.00	18.00
	24" Dia. Gravity Drains	LF	578	38.15	15.00
	36" Dia. Gravity Drains	LF	80	54.50	15.00
	24" Gate	EA	15	2,725.00	15.00
	36" Gate	EA	2	3,270.00	15.00
	Foundation Material	TN	114	23.98	15.00
	24" Dia. Culvert Removal	LF	60	19.08	15.00
	36" Dia. Culvert Removal	LF	30	27.25	15.00
	Geoweb GW 8-4 (for 8 Weirs)	SY	3,170	10.90	15.00
	Stone 1" minus (for 8 Weirs)	TN	965	23.98	15.00
	Staff Gage	EA	12	545.00	20.00
IL	**Carlyle Lake - Pool 2 Subdivisions - pg. 21**				
	Mob., Demob., & Prep. Work	LS	1	1,635.00	15.00
	Embankment	CY	23,360	2.67	15.00
	Seeding	AC	7	872.00	15.00
	Clearing	AC	7	545.00	18.00
	36" Dia. Gravity Drains	LF	34	54.50	15.00
	36" Gate	EA	1	3,270.00	15.00
	Foundation Material	TN	7	23.98	15.00
	Geoweb GW 8-4 (for 2 Weirs)	SY	850	10.90	15.00
	Stone 1" minus (for 2 Weirs)	TN	255	23.98	15.00
	Staff Gage	EA	2	545.00	20.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
	SEDIMENT LEVEE				
WY	**Jackson Hole - pg. 144**				
	Mob., Demob., & Prep. Work	LS	1	10,900.00	30.00
	Care and Diversion of Water	LS	1	2,725.00	30.00
	Sediment Levees, Width - 20'; Length - 300'	CY	1,167	15.26	30.00

TABLE 12
REPAIRS

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
LAKE PERIMETER LEVEE REPAIR					
IL	**Spring Lake - pg. 98**				
	Stripping	CY	15,000	1.58	10.00
	Unsuitable Soil Excavation	CY	9,000	3.38	20.00
	Clearing and Grubbing	AC	24	3,232.00	15.00
	Seeding	AC	24	2,125.50	10.00
	Embankment Fill, Place & Shape	CY	41,000	4.63	20.00
IL	**Spring Lake - pg. 98**				
	Stripping	CY	24,500	1.74	10.00
	Unsuitable Soil Excavation	CY	16,000	3.76	20.00
	Clearing and Grubbing	AC	39	3,880.00	15.00
	Seeding	AC	39	2,125.50	10.00
	Embankment Fill, Place & Shape	CY	105,500	4.69	20.00
	Riprap	CY	2,000	49.32	20.00
	Crushed Stone	CY	250	27.90	20.00
CROSS DIKE REPAIR					
IL	**Spring Lake - pg. 98**				
	Stripping	CY	7,000	1.58	10.00
	Unsuitable Soil Excavation	CY	4,900	3.38	20.00
	Clearing and Grubbing	AC	7	3,259.00	15.00
	Seeding	AC	8.5	2,125.50	10.00
	Embankment Fill, Place and Shape	CY	6,000	8.07	20.00
	Crushed Stone	CY	1,700	27.90	20.00
	Mob, Demob, & Prep. Work	LS	1	26,160.00	25.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
CROSS DIKE REPAIR, CONT.					
IL	**Lake Chautauqua - pg. 83**				
	Mob. & Demob.	LS	1	21,392.00	10.00
	Embankment Fill, Place & Shape	CY	121,000	3.81	20.00
	Clearing and Grubbing	AC	5.2	2,027.00	20.00
	Seeding	AC	11	1,288.00	20.00
	Crushed Stone (Permanent Access Road)	TN	1,600	21.62	20.00
	Permanent Erosion Matt	SY	1,500	11.20	20.00
	Temporary Erosion Control Matt	SY	6,000	1.40	20.00
EXISTING ROCK CLOSURE REPAIR					
IL	**Swan Lake - pg. 106**				
	Clearing and Grubbing	AC	1.50	2,021.00	17.00
	"C" Stone Repair	TN	2,000	21.66	13.00
LEVEE REPAIR					
IL	**Lake Chautauqua - pg. 83**				
	Stripping	CY	5,800	1.68	20.00
	Unsuitable Soil Excavation	CY	12,500	2.69	15.00
	Clearing/Grubbing	AC	17.7	2,027.00	20.00
	Seeding	AC	17.7	1,288.00	20.00
	Embankment Fill, Place & Shape	CY	176,000	3.98	20.00
	Embankment Fill, Shape	CY	20,000	1.79	20.00
	Riprap	TN	2,400	31.36	30.00

TABLE 13
DREDGING

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
	DREDGING				
NV	**Lower Truckee River - pg. 43**				
	Mob. & Demob.	LS	1	8,400.00	25.00
	Dredge Pilot Channel	CY	22,200	3.64	25.00
	Dredge Fishway	CY	7,000	3.64	25.00
	Dredge River Mouth	CY	7,000	3.64	25.00
	Dredge Resting Pool	CY	1,000	3.64	25.00
IA	**Bussey Lake - pg. 75**				
	Mob., Demob., & Prep. Work	LS	1	303,240.00	25.00
	Clearing and Grubbing	AC	7	3,562.00	32.90
	Control Structure	LS	1	11,400.00	25.00
	Silt Screen	FT	3,000	2.28	20.00
	Raise Existing Outlets	EA	2	7,552.00	24.80
	Modify Manhole	EA	1	712.00	16.70
	Valves in Manhole	EA	2	21,375.00	20.00
	24" CMP	LF	950	100.00	15.00
	Material Handling	CY	90,000	1.71	20.00
	Material Handling Contract	LS	1	5,700.00	23.00
	Pipeline Dredging	CY	270,000	2.57	15.00
	Mechanical Dredging	CY	26,000	6.38	25.00
	Dredged Material Disposal	CYM	26,000	0.23	25.00
	Dike Construction	CY	26,000	2.28	25.00
IL	**Potters Marsh - pg. 95**				
	Mob, Demob, & Prep. Work	LS	1	111,000	15.00
	Stump Removal	EA	50	211.00	50.00
	Hydraulic Dredging	CY	442,300	3.22	25.20
	Polymer for Dredge Discharge	LB	6,300	3.33	75.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
	DREDGING, CONT.				
IA	**Brown's Lake - pg. 72**				
	Hydraulic Dredging	CY	370,000	4.41	15.00
IL	**Spring Lake - pg. 98**				
	Mob., Demob., & Prep. Work Port Barges	LS	1	17,004.00	38.20
	Mechanical Excavation (Dredging)	CY	126,650	5.07	25.00
	Seeding	AC	7	2,725.00	20.00
	BARRIER ISLAND DREDGE				
IL	**Peoria Lake - pg. 87**				
	Mob., Demob., & Prep. Work	LS	1	88,780.00	10.00
	Dike Con/Bckt Slope Shape	CY	482,000	2.88	15.00
	Riprap	TN	5,200	30.25	15.00
	Geotextile Fabric	SY	20,000	1.84	15.00
	Temporary Seed Cover	AC	16	1,282.00	15.00
	Turbidity Control	LS	1	14,835.00	10.00
	Erosion Control Mat, Outside	SY	7,800	8.40	10.00
	Plant Sprigging thru Mat, Outside	EA	12,000	1.21	20.00
	Plant Sprigging, Inside	EA	12,000	0.81	20.00
	Woody Cuttings thru Mat, Outside	EA	19,400	1.90	15.00
	Woody Cuttings, Inside	EA	19,400	1.15	15.00
	Grass Legume Planting	AC	14	1,472.00	15.00
	Tree Seedlings	EA	500	12.77	15.00
	Turbidity Curtain, Anchors	EA	135	267.00	20.00
	Turbidity Curtain Skrt. & Hndlg.	LF	1,600	24.44	20.00
	Floating Vegetated Islands	EA	8	4,830.00	10.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
CONFINED PLACEMENT SITE					
IL	**Potters Marsh - pg. 95**				
	Selective Clearing	AC	14	1,437.00	25.00
	Embankment	CY	162,000	5.44	20.00
	Stop Log Structure	LS	1	21,090.00	25.00
	Drainage Pipe - 18" CMP	LF	200	36.63	25.00
CONFINED DISPOSAL SITE					
IA	**Brown's Lake - pg. 72**				
	Clearing	AC	43	1,890.00	15.00
	Confined Levee Fill	CY	34,900	2.52	15.00
	Mast Planting/Revegetation	AC	43	1,260.00	15.00

TABLE 14
FISH MANAGEMENT

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
FISH PASSAGE STRUCTURE					
IL	**Stump Lake - pg. 103**				
	Mob., Demob., & Prep. Work	LS	1	60,907.00	10.00
	Dewatering	LS	1	85,810.00	35.00
	Fish Passage Structure	CY	42	226.00	30.00
	Sluice Gate	EA	4	16,950.00	20.00
	Bedding Stone, 3" minus	TN	730	24.86	20.00
	Excavation	CY	1,060	1.70	20.00
	Embankment	CY	500	2.83	20.00
	Geotextile	SY	400	4.52	20.00
	Riprap	TN	10	16.95	20.00
	Cofferdam Earth	CY	590	2.83	15.00
	Guardrail	LF	56	24.86	20.00
	“B” Stone	TN	120	13.56	20.00
	Seeding	AC	0.2	1,356.00	20.00
	Clearing	AC	0.5	2,034.00	20.00
	Geogrid	SY	400	11.30	20.00
FISH LADDER AND SCREENS					
NV	**Lower Truckee River - pg. 43**				
	Flattening Existing Ladder Increasing Resting Pools by 9	LS	1	1,100,000	25.00
	One Screen at Site and 5 Upstream Screens	LS	1	132,000.00	25.00
	Fish ladder	EA	1	1,022,000.00	25.00
	Screening	EA	1	4,100,000	25.00
	Screens	EA	18	39,783.00	25.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
FISH HANDLING FACILITIES					
NV	**Lower Truckee River - pg. 43**				
	Wing Wall, rehab. river trap canal	LS	1	343,504.00	25.00
	Electric Weir	LS	1	78,400.00	25.00
	Plumbing in fish handling building	LS	1	112,000.00	25.00
FISH TRANSPORT ARTIFICIALLY					
NV	**Lower Truckee River - pg. 43**				
	Based on average haul of 6 miles per 8 yard truck.	Trip	1	448.00	25.00
FISHWAY RECONSTRUCTION					
NV	**Lower Truckee River - pg. 43**				
	Reconstruct Fishway	LS	1	27,500,000	25.00
FISH TOXICANT TREATMENT					
IL	**Lake Chautauqua - pg. 83**				
	Fish Toxicant Treatment	LS	1	67,200.00	20.00

TABLE 15
GRAVITY DRAIN

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
GRAVITY DRAIN					
IL	**Swan Lake - pg. 106**				
	Sluice Gate & Operator - 48" Dia.	EA	1	16,314.00	13.00
	CMP - 48" Diameter	LF	31	82.39	13.00
	End Sections - 48"	EA	2	1,004.00	13.00
	Riser Pipe - 72" Diameter	LF	8.5	204.00	13.00
	Concrete Base	CY	8	284.00	17.00
	Crushed Stone - 3" minus	TN	400	20.35	13.00
	Crushed Stone - 6" minus	TN	190	20.35	13.00
	Geogrid	SY	200	14.19	17.00
	Geotextile	SY	460	3.19	17.00
COFFERDAM FOR GRAVITY DRAIN					
IL	**Swan Lake - pg. 106**				
	“C” Stone	TN	5,040	21.66	13.00
	Crushed Stone	TN	230	16.68	13.00
	Plastic Liner	SY	1,360	19.15	17.00

TABLE 16
LAND DEVELOPMENT

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
SALT MARSH RESTORATION					
RI	**Galilee Salt Marsh - pg. 29**				
	Marsh Excavation	CY	24,300	14.58	0.00
	Site Access (in Marsh Areas)	LF	600	79.50	0.00
	Self-Regulating Gates	EA	4	38,280.00	0.00
	Stop logs, Hardware, & Installation	EA	1	15,000.00	0.00
	Precast Concrete Box Culvert	LF	400	583.00	0.00
	Bedding for Structures	CY	600	19.08	0.00
	Road Excavation	CY	4,000	5.00	0.00
	Utility Protection	EA	5	750.00	0.00
	Traffic Control	MD	120	240.00	0.00
	Curb Cutting	LF	100	12.00	0.00
	Misc. Plantings	LS	1	6,625.00	0.00
	Environmental Plantings	LS	1	10,600.00	0.00
	Site Grading	CY	10,420	3.71	0.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
SEASONAL WETLAND DEVELOPMENT, GRASSLAND/UPLAND DEVELOPMENT, RIPARIAN WOODLAND, & PERMANENT WETLANDS					
CA	**Yolo Basin Wetlands - pg. 62**				
	Mob., Demob, & Prep. Work	LS	1	100,800.00	12.60
	Project Signs (4' x 6')	EA	2	672	9.20
	Landscaping Marsh Plants	EA	1,860	96.88	15.00
	Planting Trees	EA	1,400	35.28	15.00
	Irrigation	LF	5,300	1.01	14.70
	Maintenance	MHR	600	29.12	14.70
	Excavate & Haul to Admin. Area	CY	80,000	1.62	15.00
	Excavate & Haul to Berms	CU	425,000	0.67	10.00
	Excavate & Haul Rip. Wood/Grass	CY	195,000	0.84	10.00
	Place Embankment at Berm	CY	550,000	0.50	10.00
	Clearing @ 3,000 AC (Rough Grading)	SY	14,520	14.67	15.00
	Seeding @ 464 AC (Rough Grading)	SY	22,460	0.50	14.80
	Crushed Base 4" Depth (Roads)	SY	219	1,714.00	15.00
	30" Diameter Culvert	LF	260	38.92	10.00
	48" Diameter Culvert	LF	130	81.76	9.50
	12" CMP	LF	320	14.73	14.30
	36" CMP	LF	1,430	36.12	15.00
	12" x 12" (Slide Gates)	EA	16	2,660.00	10.00
	36" x 36" (Slide Gates)	EA	51	5,096.00	5.00
	36" CMU Head/Wing Wall	SF	5,250	15.29	10.00
	12" CMU Head/Wing Wall	SF	210	15.29	15.00
	75 Hp. Pump w/Shed	EA	2	7,896.00	9.90

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
	GRASSLAND/UPLAND DEVELOPMENT, RIPARIAN WOODLAND, & PERMANENT WETLANDS				
CA	**Yolo Basin Wetlands - pg. 62**				
	Mob., Demob., & Prep. Work	LS	1	44,800.00	12.50
	Project Signs (4' x 6')	EA	1	672.00	8.30
	General Clearing	AC	392	274.00	15.00
	Disking and Seeding	CSY	19,000	0.56	14.70
	Planting Trees	EA	4,150	35.28	12.50
	Maintenance (3 years)	MHR	1,800	29.12	15.00
	Excavate & Haul to Waste	CY	16,700	1.62	14.90
	Excavate & Haul to Berms	CY	6,400	1.12	9.40
	Place Embankment at Berm	CY	4,500	0.50	9.90
	Clearing @ 480 AC (Rough Grading)	SY	2,330	14.67	15.00
	Crushed Base 4" Depth (Roads)	SY	89	1,714.00	14.00
	36" Diameter CMP	LF	140	36.06	11.10
	Fence and Gate (12' x 6')	EA	1	689.00	16.30
	200 GPM Pump (2" discharge)	EA	1	3,567.00	9.40
	Electric line (incl. 1 Pole)	LF	300	3.30	11.30

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
	SEASONAL WETLAND DEVELOPMENT, RIPARIAN WOODLAND, & PERMANENT WETLANDS				
CA	**Yolo Basin Wetlands - pg. 62**				
	Mob., Demob., Prep. Work	LS	1	44,800.00	12.50
	Project Signs (4' x 6')	EA	1	672.00	8.30
	Landscaping Marsh Plants	EA	115	269.00	14.90
	Planting Trees	EA	3,250	35.28	15.00
	Maintenance (3 years)	MHR	1,200	29.12	9.90
	Excavate & Haul to Waste	CY	220,000	1.62	15.00
	Excavate & Haul to Berms/Islands	CY	400,000	0.67	9.50
	Place Embankment at Berm	CY	320,000	0.50	10.00
	Clearing @ 345 AC (Rough Grading)	MSY	1,670	14.67	15.00
	Graded Crushed Aggregate (Roads)	TN	7,000	23.52	15.00
	12" Diameter CMP	LF	840	13.27	10.00
	24" Diameter CMP	LF	800	23.18	10.30
	36" Diameter CMP	LF	230	36.12	9.40
	12" x 12" Slide Gates	EA	28	2,660.00	15.00
	36" x 36" Slide Gates	EA	2	5,096.00	15.40
	CMU Head/Wing Wall	SF	100	20.89	10.20
	Bypass Diversion Structure	SF	120	16.02	11.70
	Stop Logs	BF	100	2.24	15.00
	12.5 Hp Pump w/Shed	EA	4	1,624.00	10.30
	WETLANDS CREATION				
NV	**Lower Truckee River - pg. 43**				
	Mob. & Demob.	LS	1	2,240.00	25.00
	Care and Diversion of Water	LS	1	3,360.00	25.00
	Excavation	CY	300	2.80	25.00
	Embankment	TN	1,030	22.40	25.00

TABLE 17
MISCELLANEOUS

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
INTERIOR CLOSURE					
IL	**Swan Lake - pg. 106**				
	Excavation	CY	12,200	6.48	20.00
	Clearing	AC	1	2,021.00	13.00
	"C" Stone Revetment	TN	11,250	21.66	13.00
	Crushed Stone CA-10	TN	75	16.68	13.00
OTHER MISCELLANEOUS					
IL	**Swan Lake - pg. 106**				
	Automatic Gaging Station	EA	3	13,596.00	13.00
	Staff Gage	EA	6	1,369.00	13.00
	Silt Screen	SF	12,000	6.80	13.00
	Water Quality Tests	EA	160	67.97	13.00

TABLE 18
PARKING LOT AND BOAT RAMP

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
PARKING LOT AND BOAT RAMP					
IL	**Swan Lake - pg. 106**				
	CA-10 Crushed Stone	TN	690	16.68	13.00
	Quarry-run Stone - Boat Ramp	TN	145	20.79	17.00
	Semi-compacted Embankment	CY	1,485	4.89	20.00
	Stripping	CY	470	2.86	13.00
	Seeding	AC	0.20	1,727.00	17.00
	Clearing	AC	0.30	2,109.00	17.00
	14' Access Gate	EA	1.00	3,547.00	17.00
IL	**Swan Lake - pg. 106**				
	CA-10 Crushed Stone	TN	660	16.68	13.00
	Quarry-run Stone - Boat Ramp	TN	145	20.79	17.00
	Semi-compacted Embankment	CY	1,465	4.89	20.00
	Stripping	CY	470	2.86	13.00
	Seeding	AC	0.20	1,727.00	17.00
	Clearing	AC	0.30	2,109.00	17.00
	CMP-18" Diameter	LF	30	29.92	13.00
	CMP End Section - 18"	EA	2	296.22	13.00
	Crushed Stone - 1" minus	TN	3	16.32	14.00
BOAT RAMP REPLACEMENT					
IL	**Lake Chautauqua - pg. 83**				
	Boat Ramp Replacement	LS	1	67,760.00	25.6

TABLE 19
PUMP STATION AND PUMPING PLANT

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
PUMP STATION AND PUMPING PLANT					
MO	**Bay Island - pg. 69**				
	Excavation	CY	175	5.80	50.00
	Dewatering	LS	1	5,800.00	50.00
	Backfill	CY	50	11.60	50.00
	Structural Concrete	CY	65	464.00	50.00
	24" RCP	LF	116	29.00	30.00
	Trash Rack, Ladder, Man Holes, Etc.	LS	1	6,969.00	30.00
	Pump Motor, Discharge Pipe	LS	1	42,920.00	30.00
	Power Supply	LS	1	17,400.00	30.00
IL	**Spring Lake - pg. 98**				
	Dewatering	LS	1	121,099.00	20.00
	Excavation	CY	1,200	3.98	10.00
	Structural Concrete	CY	140	649.00	25.00
	Slide Gate	EA	1	15,260.00	10.00
	Trash Rack Assemblies	LS	1	6,976.00	20.00
	48" Discharge Pipe, RCP & Cradle	LF	90	276.00	15.00
	Riprap	CY	535	49.32	20.00
	Buried Primary Feeder & Transformer	LS	1	65,400.00	15.00
	Misc. Electrical	LS	1	29,648.00	15.00
	Electric Platform Assembly	EA	1	8,546.00	15.00
	Submersible Pumps	EA	2	67,951.00	15.00
	Timber Piling	LF	1,550	14.50	30.00
	Material Handling to Site	LS	1	10,573.00	10.00
	Backfill	CY	1,176	8.39	15.00
	Misc. Metals	LS	1	24,710	15.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
PUMP STATION AND PUMPING PLANT, CONT.					
IL	**Stump Lake - pg. 103**				
	Mob., Demob., & Pep. Work	LS	1	9,831.00	10.00
	Pump (48,000 GPM)	EA	2	80,796.00	25.00
	Portable Pump (5,000 GPM)	EA	1	31,584.00	30.00
	Pump Driver (for 48,000 GPM)	EA	1	31,292.00	30.00
	42" Diameter Steel Pipe (3/8")	LF	730	113.00	20.00
	42" Diameter Flap Gate	EA	2	9,266.00	10.00
	6' Chain Link Fence w/3-Strand Barb Wire	LF	300	22.60	15.00
	Fence Gate (6' x 10')	EA	2	169.50	15.00
	Clearing and Grubbing	AC	0.7	2,034.00	20.00
	Seeding	AC	0.5	1,356.00	20.00
	Embankment	CY	805	4.52	15.00
	Concrete Curb	CY	1.00	452.00	15.00
	Riprap	TN	480.00	16.95	15.00
	Excavation	CY	705	2.26	20.00
	Ditching	CY	880	2.83	20.00
	Cofferdam “C” Stone & Removal	TN	1,200	18.08	20.00
IL	**Swan Lake - pg. 106**				
	Reinforced Concrete	CY	400	354.66	17.00
	Structural Steel	LB	26,400	2.49	17.00
	Sluice Gate w/Operator - 72" x 72"	EA	2	32,510.00	20.00
	Slide Gate w/Hardware - 72" x 72"	EA	2	17,733.00	20.00
	Geotextile	SY	1,070	3.06	13.00
	Stoplogs (4 x 6 Oak Timbers)	SF	1,280	4.44	22.00
	Concrete Parking Blocks	EA	4	40.43	17.00
	Crushed Stone CA-10	TN	30	16.68	13.00
	Pump and Accessories	EA	2	90,919.00	13.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
PUMP STATION AND PUMPING PLANT, CONT.					
IL	**Swan Lake, cont. - pg. 106**				
	Gantry Crane w/Hoist	EA	2	1,107.00	17.00
	Structural Excavation	CY	6,000	3.04	17.00
	Excavated Embankment	CY	6,000	2.98	17.00
	Embankment, Borrow	CY	3,200	6.36	13.00
	Dewatering	LS	1	89,261	20.00
	Ditch Excavation	CY	14,350	3.98	13.00
	Clearing for Ditch Excavation	AC	1	2,109.00	17.00
	“C” Stone for Ditch Excavation	TN	1,725	21.66	13.00
	Fish Screens	EA	2	559.00	26.00
IL	**Lake Chautauqua - pg. 83**				
	Dewatering	LS	1	24,640.00	25.00
	Structural Concrete	CY	360	504.00	15.00
	Slide Gates, 5' x 5'	EA	2	13,440.00	15.00
	Trash Rack Assemblies	EA	3	4,816.00	15.00
	Discharge Pipe, 48" Steel	LF	200	269.00	20.00
	Flap Gate, 48"	EA	1	4,480.00	15.00
	Riprap	TN	620	30.24	30.00
	Buried Primary Feeder	FT	5,500	13.16	15.00
	Transformer	EA	1	13,776.00	15.00
	Misc. Electrical	LS	1	8,590.00	20.00
	Electrical Platform Assembly	LS	1	17,136.00	15.00
	Submersible Pump & Accessories	LS	1	113,120.00	20.00

TABLE 20
RADIAL GATE STRUCTURE

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
MODIFICATION OF EXISTING RADIAL GATE STRUCTURE					
IL	**Lake Chautauqua - pg. 83**				
	Site Preparation	LS	1	11,200.00	30.00
	Structural Concrete	CY	110	56,056.00	15.00
	Stop Log Assembly	EA	8	17,920.00	20.00
	Bar Grates	EA	8	8,960.00	20.00
	Port Gate Power Generator	EA	1	3,360.00	20.00
	Geared Gate Lifters	EA	4	5,376.00	20.00
	Riprap	TN	3,000	90,720.00	30.00

TABLE 21
ROADS AND BRIDGES

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
	ROADS				
MO	**Bay Island - pg. 69**				
	Crushed Stone Surface	TN	2,000	23.20	50.00
IL	**Potters Marsh - pg. 95**				
	Crushed Stone (Existing Rd.)	TN	300	23.20	20.00
	Clearing and Grubbing	AC	1.5	5,789.00	25.00
	Embankment	CY	1,870	4.11	20.00
	Drainage Pipe - 24" CMP	LF	40	42.62	25.00
	Crushed Stone	TN	1,605	23.20	20.00
	Mechanical Excavation\Access Rd.	CY	4,700	9.44	15.00
IL	**Spring Lake - pg. 98**				
	Clearing and Grubbing	AC	0.6	3,232.00	15.00
	Grade Access Road	SY	2,700	1.09	50.00
	Crushed Stone	CY	320	27.90	20.00
IL	**Stump Lake - pg. 103**				
	Mob., Demob., & Prep. Work	LS	1	997.00	10.00
	24" CMP	LF	100	28.25	20.00
	24" End Sections	EA	2	203.00	20.00
	Crushed Stone	TN	350	13.56	20.00
	Clearing and Grubbing	AC	0.5	2,034.00	20.00
	Quarry-run Stone (6" minus)	TN	300	16.95	20.00
	Earth Fill (Semi-Comp.)	CY	1,380	4.52	20.00
IL	**Swan Lake - pg. 106**				
	Crushed Stone CA-10	TN	1,780	16.24	11.00
	Stripping	CY	1,565	2.86	13.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
	ROADS, CONT.				
IL	**Swan Lake - pg. 106**				
	Semi-compacted Embankment	CY	900	4.89	20.00
	Crushed Stone CA-10	TN	275	16.24	11.00
IL	**Swan Lake - pg. 106**				
	Semi-compacted Embankment	CY	90	4.89	20.00
	Crushed Stone CA-10	TN	60	16.24	11.00
	ACCESS ROAD BRIDGE				
MO	**Bay Island - pg. 69**				
	Prefab. Deck & Wearing Surface	LS	1	23,200.00	25.00
	Structural Concrete	CY	54	464.00	30.00
	Granular Backfill	TN	675	20.88	50.00
	Steel Guardrail	LF	180	29.00	50.00

TABLE 22
SUBIMPOUNDMENTS

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
	SUBIMPOUNDMENTS				
MN	**Orwell Lake - Subimpoundment #2 - pg. 53**				
	Sheet Pile Control Structure	SF	860	28.82	39.80
	Mob, Demob and Prep Work	LS	1	2,590.00	52.20
	Embankment	CY	190	4.24	28.60
	Stoplog (4"W x 6"H x 5'3"L)	EA	16	13.56	0.00
	Structure Type III Riprap	CY	82	7.24	20.00
	Structure Type IV Filter Fabric	SY	136	4.11	20.00
	Fertilize, Seed, Mulch	AC	0.05	2,341.00	0.00
	Topsoil	CY	23	13.76	33.30
MN	**Orwell Lake - Subimpoundment #7 - pg. 53**				
	Mob, Demob & Prep Work	LS	1	2,228.00	50.00
	Embankment	CY	600	4.24	33.40
	Channel Excavation	CY	600	2.14	36.40
	Control Structure	JOB	1	1,100.00	40.00
	36" C.S.P.	LF	36	63.22	15.00
	72" x 96" Anti Seep Diaphragm	EA	1	504.00	20.00
	Fertilize, Seed & Mulch	AC	0.38	2,341.00	25.00
	Topsoil	CY	204	13.76	20.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
SUBIMPOUNDMENTS					
MN	**Orwell Lake - Subimpoundment #9 - pg. 53**				
	Mob, Demob and Prep. Work	LS	1	3,298.00	51.70
	Channel Excavation	CY	5,780	3.79	40.00
	Fertilize, Seed & Mulch	AC	1	2,341.00	20.00
	2' Riprap	CY	67	7.24	25.00
	1.5' Riprap	CY	62	7.24	25.00
	Sheet Pile Control Structure	SF	1,800	20.98	40.10
	Stoplogs (4'W x 6"H x 5'3"L)	EA	16	13.56	0.00
	Geotextile	SY	223	4.11	25.00
	Supply Seed & Chemical	AC	115	134.40	0.00

TABLE 23
WATER SUPPLY

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
	FORESTED WETLAND MANAGEMENT AREA WATER SUPPLY DISCHARGE ASSEMBLY				
IL	**Peoria Lake - pg. 87**				
	Excavation	CY	30	4.37	10.00
	Structural Backfill	CY	22	13.80	15.00
	Structural Concrete	CY	13	437.00	15.00
	Concrete Pipe Riser	LS	1	483.00	15.00
	Misc. Metals	LS	1	362.25	15.00
	FORESTED WETLAND MANAGEMENT AREA WATER SUPPLY PUMP STATION				
IL	**Peoria Lake - pg. 87**				
	Excavation	CY	65	4.37	10.00
	Dewatering	LS	1	5,922.00	15.00
	Structural Backfill	CY	30	13.80	15.00
	Structural Concrete	CY	20	437.00	15.00
	Crushed Stone Bedding	TN	6	25.88	15.00
	Trash Rack, Misc Metals	LS	1	4,600.00	20.00
	Pump, Motor, Discharge Pipe	LS	1	73,847.00	15.00
	Buried Primary Electrical Feeder	LF	800	13.28	15.00
	Transformer	EA	1	10,425.00	20.00
	Phase Converter	EA	1	13,628.00	20.00
	Misc. Electrical	LS	1	3,795.00	15.00
	Electrical Platform Assembly	LS	1	3,392.00	15.00
	Water Supply Pressure Pipe	LF	400	59.80	10.00

TABLE 24
WATER CONTROL STRUCTURES

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
CHANNEL TO AND FROM WATER CONTROL STRUCTURE					
IA	**Brown's Lake - pg. 72**				
	Clearing	AC	1	2,520.00	15.00
	Excavation	CY	6,300-8,600	4.41	15.00
	Seeding	AC	2-5	1,890.00	15.00
GATE WELL/CULVERT SYSTEMS FOR LAKES					
MN	**Finger Lakes - pg. 78**				
	Mob, Demob, & Prep. Work	LS	1	5,700.00	20.00
	Ditch Excavation	CY	3,000	2.28	33.00
	Clearing and Grubbing	AC	2	2,280.00	25.00
	Dewatering (Cofferdams)	LS	1	9,120.00	50.00
	Dewatering (Wells)	LF	150	57.00	50.00
	Pipe through Dam (42" Diameter)	LF	100	108.30	20.00
	Pipe through Dam (48" Diameter)	LF	100	119.70	27.00
	Pipe downstream of Dam (42" Dia.)	LF	250	188.00	20.00
	Pipe downstream of Dam (48" Dia.)	LF	760	199.50	20.00
	Gatewell	LS	1	27,360.00	21.00
	Sluice gate w/operator (42")	LS	1	20,520.00	22.00
	Sluice gate w/operator (48")	LS	1	22,800.00	20.00
	42" Diameter Bend	EA	1	1,140.00	100.00
	48" Diameter Bend	EA	1	2,280.00	50.00
	42" Trash Rack	EA	1	3,420.00	33.00
	48" Trash Rack	EA	1	3,420.00	33.00
	Scour Hole	EA	2	4,560.00	25.00
	Channel Excavation, Upst. of Dam	LS	1	5,700.00	20.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
GATE WELL/CULVERT SYSTEMS FOR LAKES, CONT.					
MN	**Finger Lakes - pg. 78**				
	Mob, Demob, & Prep. Work	LS	1	5,700.00	25.00
	Clearing and Grubbing	AC	0.5	2,280.00	100.00
	Dewatering (Cofferdams)	LS	1	9,120.00	50.00
	Dewatering (Wells)	LS	150	57.00	25.00
	Pipe through Dam (36" Diameter)	LF	150	91.20	25.00
	Pipe downstream of Dam (36" Dia.)	LF	150	168.00	22.00
	Gatewell	LS	1	14,820.00	23.00
	Sluice Gate w/Operator	LS	1	13,680.00	25.00
	36" Trash Rack	EA	1	3,420.00	33.00
	Scour Hole	EA	1	4,560.00	25.00
GRAVITY OUTLET					
IL	**Lake Chautauqua - pg. 83**				
	Dewatering	LS	1	19,040.00	25.00
	Structural Concrete	CY	47	504.00	15.00
	60" R.C.P. & Concrete Cradle	EA	112	269.00	15.00
	Trash Rack Assembly	EA	2	2,576.00	15.00
	Slide Gate Assembly	EA	1	13,552.00	15.00
	Riprap	TN	380	30.24	30.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
INLET/WATER CONTROL STRUCTURE					
IL	**Spring Lake - pg. 98**				
	Embankment Fill	CY	1,100	8.39	10.00
	Excavation	CY	1,700	3.87	10.00
	Structural Concrete	CY	350	556.00	10.00
	Dewatering	LS	1	102,946.00	20.00
	Slide Gates	EA	2	15,260.00	10.00
	Trash Racks	EA	2	4,153.00	15.00
	Riprap	CY	250	49.32	20.00
	Timber Piling	LF	2,640	14.50	30.00
	Sand Bedding	CY	235	29.98	20.00
TWO GATED WATER CONTROL STRUCTURE TO REGULATE WATER SALINITY					
TX	**McFaddin Ranch Wetlands - pg. 51**				
	Stripping	SY	9,280	0.54	20.00
	Channel Excavation	CY	24,790	2.06	30.00
	Blanket Stone	TN	2,450	43.78	25.00
	Riprap	TN	5,330	42.93	25.00
	Fill from Borrow Excavation	CY	6,130	3.73	30.00
	Fill from Sidecast Borrow	CY	1,025	2.21	20.00
	Fill from off-site Borrow	CY	1,900	13.40	40.00
	Gated Structure	LS	1	544,851.00	30.00
	Roller Boat Ramp	LS	1	85,459.00	25.00
	Final Grading	SY	15,210	0.45	25.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
WATER CONTROL STRUCTURE					
IA	**Brown's Lake - pg. 72**				
	Embankment Fill	CY	5,200	7.56	15.00
	Excavation	CY	3,100	7.56	15.00
	Concrete	CY	485	441.00	15.00
	Dewatering	Days	60	378.00	15.00
	Slide Gates	EA	4	10,080.00	15.00
WATER CONTROL STRUCTURE AND GRAVITY DRAINAGE STRUCTURE PERIMETER (EXTERIOR) & INTERMEDIATE (INTERIOR) LEVEES					
MO	**Bay Island - pg. 69**				
	Sheet Pile Cutoff	SF	800-1,085	17.40	20.00
	Structural Concrete	CY	50-66	464.00	30.00
	Grating	SF	96-276	29.00	30.00
	Steel Guardrail	LF	60-88	29.00	50.00
	Stop Logs	LF	50-240	2.32	25.00
	Riprap	TN	40-75	29.00	20.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
WATER CONTROL STRUCTURE AND GRAVITY DRAINAGE STRUCTURE PERIMETER (EXTERIOR) & INTERMEDIATE (INTERIOR) LEVEES, CONT.					
IL	**Stump Lake - pg. 103**				
	Excavation	CY	1,291	1.70	20.00
	Plastic Liner	SY	1,170	15.26	20.00
	Geogrid	SY	680	11.30	20.00
	Cofferdam Graded Stone “C”	TN	1,565	18.08	20.00
	“C” Stone	TN	760	12.43	20.00
	“B” Stone	TN	798	13.56	20.00
	6" minus Bedding	TN	430	16.95	20.00
	3" minus Bedding	TN	1,030	16.95	20.00
	42" Diameter CMP	LF	212	73.45	15.00
	Geotextile	SY	340	4.52	20.00
	72" Diameter Riser Structure (incl. sluice gates and appurtenances)	EA	6	25,990.00	25.00
	Hydraulic Operator	EA	1	11,300.00	50.00
	Gaging Station	EA	1	14,690.00	20.00
	Concrete Pad	CY	5.40	143.92	20.00
	Removal of 2-36"CMP	LS	1	3,390.00	25.00
	24" CMP Culvert	LF	46	28.25	25.00
	24" End Section	EA	1	226.00	25.00

STATE	ITEM/COMPONENTS	UNIT	QUANTITY	UNIT PRICE 1995 P.L.	CONTINGENCY (%)
WATER CONTROL STRUCTURE (LAKE) - STOP LOG STRUCTURE					
IL	**Lake Chautauqua - pg. 83**				
	Dewatering	LS	1	17,696.00	25.00
	Excavation	CY	555	4.42	15.00
	Structural Backfill	CY	300	19.26	25.00
	Structural Concrete	CY	125	409.00	15.00
	Steel Guardrail	LF	100	44.80	20.00
	Stop Logs	LF	310	2.86	20.00
	Riprap	TN	155	30.24	30.00
	Heavy Duty Grating	SF	276	50.40	20.00
	Sheet Pile Cutoff	SF	1,600	16.80	20.00

CHAPTER VIII - CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Fifty-two Corps of Engineers studies from 16 different districts and divisions in various planning and construction phases were described. Studies from the Section 1135 Program, the Upper Mississippi River System - Environmental Management Program, the Louisiana Coastal Wetlands Restoration Plan, various flood reduction projects with environmental features, and beneficial uses of dredged material projects were described. Provided for each of the projects were their objectives and goals, types of engineering features, benefits and/or outputs, and the estimated total cost.

A variety of objectives and goals were identified from these studies. They included restoring salt marshes, reducing saltwater intrusion, restoring barrier islands, restoring wetlands, restoring stream channels and rivers, reducing sedimentation, improving water level control, utilizing available sedimentation, reducing flood damages, and preserving environmental resources. The benefits and outputs were measured in many different ways. Most of these measures were in acres, habitat units, increases in percentage of improvement above the without project condition, and average annual flood reduction benefits.

The studies reviewed included a total estimated cost. These total costs were updated to the October 1995 Price Level (P.L.). Approximately half of the studies included an MCACES estimate. Unit pricing of item/components of various engineering features was illustrated in Tables 10-24. Comparing unit pricing, total project costs, types of benefits and outputs, and the locality of the reported projects would be a rather difficult task. Cost accounting on past restoration projects apparently have not been well documented to be of practical use (IWR Report 95-R-3 and IWR Report 95-R-12). Standard construction cost guidebooks (e.g., Means, Dodge and Kerr) provide some reasonable cost assessments for restoration projects. But to implement restoration techniques at various scales, the type of estimates needed cannot be found in published literature. This is a very popular field topic, as several agencies and interests are laboring to attain what the actual costs are and how to apply these costs when formulating alternative plans. Until such time as more documentation on this subject is available, reliance will be made heavily on standard construction cost information. It is very important that Cost Engineers be a part of the study team, as they are an essential part of the formulation of plans during each phase of the project.

The main objective of this report was to describe different types of management measures or engineering features that Corps districts and divisions have been applying in formulating alternatives for their environmental projects. Many different types of engineering features were found in the cross section of studies examined. They included a single engineering type feature at one site, several features at one site, the same type of feature at several sites, several features at several sites, and combinations of all of the above.

It appeared that in most, if not all, of the projects, the formulation of alternatives were team efforts, including outside agencies, local interests, and the local sponsor. In some cases, alternatives were pursued that other districts and/or outside agencies had implemented elsewhere in similar situations. This is another indication of the value of a descriptive review of previous studies for study managers to see what is being implemented elsewhere.

Recommendations

It is recommended that another series of Corps and non-Corps environmental studies be compiled and analyzed. There are many more engineering features/management measures that need to be assembled into a consolidated source for study team members to know what is available to best meet their objectives and goals. This report, the *National Review of non-Corps Environmental Restoration Projects*, IWR Report 95-R-12, the *Prototype Information Tree for Environmental Restoration Plan Formulation and Cost Estimation*, IWR Report 95-R-3, and an illustrated handbook of the various environmental engineering features are starts to such a consolidated source. The Final Procedures Manual for this work unit will be a compilation of all these reports. But, as more projects are built and found either productive or unresponsive, similar information needs to be documented and distributed. Implementation of the use of products from EEIRP and other research programs may enhance future documentation. As experience with these products and projects expands, there may be more consistency between objectives, output measures, and improved cost documentation. This would make comparisons between projects more enlightening.

Another recommendation is to provide the above, not only in a written format, but in some type of automated software. This software could be widely distributed to project/study managers. The database could be readily expanded and upgraded as implementation and research continues. As mentioned in IWR Report 95-R-3, there are three (3) software options for this information to be readily accessible to project planners: 1) standard database software, 2) expert system software, and 3) hypertext and hypermedia systems. A previous survey of field planners indicated the two (2) most requested alternatives for presenting this type of information were written materials and hypertext and hypermedia systems (to include the World Wide Web).

If software is developed, one other recommendation would be to interconnect this software with other software developed within EEIRP, such as the *ECO-EASY* software developed under the Cost Effectiveness work unit. Once the engineering features and/or alternatives and their costs are determined by the team members, they could be automatically imported to the *ECO-EASY* program to conduct cost effectiveness and incremental cost analysis.

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